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Human Health Risk Assessment for the Use of Pesticides in USDA Forest Service Nurseries

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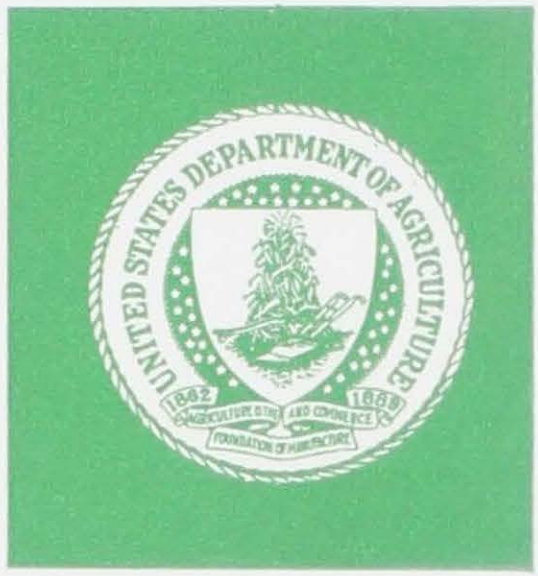

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FS-412

Human Health Risk Assessment for the Use of Pesticides in USDA Forest Service Nurseries

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Arlington, VA

Prepared for the U.S. Department of Agriculture,
Forest Service, Forest Pest Management, Larry L. Gross,
project leader, under contract 53-3187-4-22

October 1987

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Executive Summary

The USDA Forest Service operates 11 bareroot tree seedling nurseries in eight States. About half of the total area of the 11 nurseries (1,179 of 2,351 acres) is treated annually with pesticides. Twenty-eight different pesticides, including herbicides, fungicides, fumigants, and insecticides, are applied as needed to control the growth of weeds, diseases, and insects. Nursery managers use only those pesticides among the 28 that they have determined will be most effective in their particular nursery.

The analysis of human health risks from the use of the 28 pesticides was accomplished using the methodology of risk assessment widely accepted by the scientific community. In essence, the nursery pesticide risk assessment compares pesticide doses that people may get with doses shown likely to be safe to humans in long-term studies on laboratory test animals. Doses were estimated for people who may be exposed in applying the pesticides, in working in the seedbeds or with the tree seedlings, or by being near an application site.

For the pesticides that could possibly cause cancer, the risk of a person developing cancer in his or her lifetime was based on animal studies that related the chances of developing tumors to increasing pesticide doses. The risk assessment also examined whether any of the nursery pesticides was likely to cause heritable mutations, synergistic or cumulative effects, or effects on sensitive individuals. Because none of the nurseries uses all 28 pesticides, the risk assessment was done on all the pesticides in a "generic" nursery and the results were then applied to assess the risks of the pesticides used in each individual nursery (see appendix II).

The following 28 pesticides were examined in the risk assessment:

Herbicides

Atrazine	Dicamba	Oxyfluorfen
Bifenox	Diphenamid	Sethoxydim
2,4-D	Glyphosate	Simazine
DCPA	Napropamide	

Fungicides

Benomyl	DCNA	Thiram
Captan	Metalaxyl	Triadimefon
Chlorothalonil	Maneb	

Insecticides

Carbaryl	Diazinon	Fenvalerate
Chlorpyrifos	Dimethoate	

Fumigants

Dazomet	Methyl bromide + chloropicrin
1,3-Dichloropropene	Vorlex®

The risk assessment used a conservative approach that tended to exaggerate the estimated risks to human health. Assumptions about the nursery pesticide applications, about the work with the seedbeds and seedlings, and about pesticide movement and degradation tended to overestimate the doses workers and the public would be likely to receive. Toxicity levels used to judge risks were the dose levels where no systemic or reproductive effects were seen in the most sensitive laboratory test animals. Cancer potencies were derived from data on the species and sex with the highest tumor rate. In addition, the model that used the potencies to quantify cancer risk is the most conservative now in use. This conservatism, both in estimating exposures and in setting and extrapolating from toxicity levels, led to an exaggeration of the real risks of the nursery pesticide application program to ensure that it erred on the side of protecting human health.

RISK ASSESSMENT STRUCTURE AND METHODS

The risk assessment consisted of three steps: a hazard analysis, an exposure analysis, and a risk analysis.

In the hazard analysis, toxicity studies in the open literature and publicly available summaries of proprietary data were reviewed to determine the toxic properties of each pesticide. Each review included acute (single dose), subchronic (short-term dosing), and chronic (long-term or lifetime dosing) laboratory toxicity studies that showed effects caused by dermal, inhalation, and ingestion exposures. Threshold toxicity values that included acute oral LD_{50}'s and systemic and reproductive no-observed-effect levels (NOEL's) were determined for each pesticide. The hazard analysis also reviewed available results of mutagenicity assays and cancer studies and developed cancer potency values for 13 of the 28 pesticides (atrazine, 2,4-D, glyphosate, oxyfluorfen, benomyl, captan, chlorothalonil, maneb, carbaryl, dazomet, 1,3-dichloropropene, methyl bromide, and Vorlex) that had positive cancer tests.

The exposure analysis estimated the pesticide exposures and resultant doses to workers and the public from activities related to Forest Service nursery operations. Exposures were estimated for routine applications and for possible accidents. Workers at risk included pesticide applicators and other nursery personnel, such as weeders and tree lifters. The public at risk included nearby residents who could be exposed through the drift of pesticide spray droplets or vapors, by eating food items with pesticide residues, or by drinking water containing residues.

Exposure scenarios that were simplified descriptions of spraying operations and other nursery tasks and of potential routes of human exposure were used to estimate a range of possible human exposures, from most likely to extremely unlikely. "Routine-realistic" scenarios were used

to estimate the doses that workers and the public may reasonably be expected to receive as a result of routine pesticide applications. "Routine-extreme" scenarios were used to give higher dose estimates that are not likely to be exceeded except in the case of an accident.

Accident scenarios were used to estimate doses to workers that may result from direct exposure to the spray mix or concentrate or from premature reentry into treated beds, and to workers who may be downwind of an accidental spill of a fumigant. The risks to the public from accidents were considered minimal because the nurseries are fenced, access to the public is limited, and no aerial applications are done. Therefore, the public was assumed to be exposed only to an accidental spill of fumigant.

Estimates of worker exposures and doses were based on field studies of agricultural workers. Exposures and doses to the public were either extrapolated from the field worker data or calculated from pesticide drift rates, dermal exposure and absorption rates, and food intake rates using realistic and extreme assumptions concerning pesticide residue levels.

Routine worker exposures were estimated for:

- Mixer/loader/applicators
- Weeders, irrigators
- Inventory personnel
- Lifters, sorters, packers, and tree planters
- Fumigators
- Tarp lifters
- Seed treaters
- Root treaters

Routine public exposures were estimated for exposure to residues by:

- Eating a garden vegetable
- Eating beef from grazing cattle
- Eating an exposed rabbit or grouse
- Drinking water with drift residues
- Drinking water with runoff residues
- Absorption through the skin from direct exposure
- Absorption through the skin from petting an exposed cat or dog

For each of the public exposure routes, residue levels were estimated at two distances from the nursery: 100 feet (routine-realistic) and 25 feet (routine-extreme).

The risk analysis was conducted after the worker and public exposures were estimated by comparing the scenario-based dose estimates with the toxicity levels found in the hazard analysis. For threshold effects, the doses were compared to systemic and reproductive NOEL's determined in the

most sensitive test animal species. A margin of safety (MOS), the animal NOEL divided by the smaller estimated human dose, was computed to relate the doses and effects seen in animals to estimated doses and possible effects in humans. For example, an animal NOEL of 20 mg/kg divided by an estimated human dose of 0.2 mg/kg gives an MOS of 100. A margin of safety of 100 is comparable to the 100-fold safety factor that is the generally recognized value for setting safe doses for humans. The larger the margin of safety (the smaller the estimated human dose compared to the animal NOEL), the lower the risk to human health.

A cancer risk analysis was conducted when a pesticide (or a contaminant or breakdown product) tested positive in a cancer study on laboratory animals. The cancer analysis was done using estimates of lifetime doses to workers or the public and estimates of cancer potency derived in the hazard analysis. The risk of any of the 28 pesticides causing heritable mutations was judged on a qualitative rather than a quantitative basis, with a statement of the probable risk based on the available evidence of mutagenicity and carcinogenicity.

RISK ASSESSMENT CONCLUSIONS

Public Risk of Threshold Effects

The risks to the public of health effects from the use of all herbicides and fungicides and for the use of the insecticides carbaryl, dimethoate, and fenvalerate are negligible. Public margins of safety for the "routine-realistic" exposures based on systemic and reproductive NOEL's were greater than 100 for all of the nursery herbicides, for all of the fungicides, and for the insecticides carbaryl, dimethoate, and fenvalerate. Routine applications of these nursery pesticides could take place every day and the public still would not suffer any ill effects from exposure.

The insecticides chlorpyrifos and diazinon present some risk of systemic effects from cholinesterase inhibition, although these effects are likely to be minor and transitory. Chlorpyrifos doses also present some minor risk of effects on pregnant women.

The public is at slight risk from routine-extreme exposures of captan, chlorpyrifos, dimethoate, and diphenamid. There is a slightly higher risk of oxyfluorfen systemic effects and for cholinesterase inhibition from diazinon, although the risk of severe effects from either pesticide is negligible. Highest public risks are from eating vegetables 25 feet offsite.

All MOS's for routine-realistic and routine-extreme public exposure to fumigants are lower than 100, so it is likely that individuals exposed in these situations will experience some low-level effects, such as eye and lung irritation, should they be immediately downwind of a fumigation operation. As in the case of insecticide exposure, the toxic symptoms should be transitory with no long-term consequences to health.

There is an increased risk of toxic effects to the public from fumigant spill accidents. Accidental releases of methyl bromide and chloropicrin pose a greater risk because the exposures exceed the NOEL's. However, the extremely irritative properties of these chemicals should reduce any exposure time and any toxic effects should be transitory.

Public Risk of Nonthreshold Effects

Cancer risks for the pesticides are low. Available laboratory evidence indicates that bifenox, DCPA, dicamba, diphenamid, napropamide, sethoxydim, simazine, DCNA, metalaxyl, thiram, triadimefon, chlorpyrifos, diazinon, and fenvalerate do not cause cancer.

Only in the cases of 30 lifetime exposures to maneb and atrazine are the risks of cancer greater than 1 in 1 million (1.0×10^{-6}). In no instance does the public cancer risk exceed 1 in 100,000 (1.0×10^{-5}). Cancer risk resulting from accidental fumigant exposure does not exceed 1 in 1 million. However, multiple public fumigant exposures under routine conditions may result in higher risks. After 10 years of exposure, cancer risk from methyl bromide fumigation may be 2 in 100,000; for 1,3-dichloropropene, 6 in 1 million.

Mutagenic risks appear to be low for most of the nursery pesticides. Glyphosate, fenvalerate, metalaxyl, diphenamid, sethoxydim, triadimefon, 1,3-dichloropropene, methyl bromide + chloropicrin mixtures, and Vorlex tested negative for mutagenicity in all assays conducted, and thus can be considered to pose no mutagenic risk. Bifenox and DCPA also tested negative in all mutagenicity tests. Chlorpyrifos is considered by EPA to be nonmutagenic. EPA has also concluded that chlorothalonil is not mutagenic in mammals. Dicamba, simazine, and napropamide were nonmutagenic in most of the assays performed, so their mutagenic risk should be extremely limited.

EPA-validated data are insufficient to determine whether DCNA, diazinon, or dazomet are mutagenic, but it appears that their probability of causing heritable mutations is low because they have not been shown to cause cancer in any long-term studies. Although carbaryl may be weakly mutagenic, EPA has concluded that present information does not indicate that it is a mutagenic hazard to humans.

Fifteen of 17 studies found in the open literature were positive for thiram. Because dimethoate tested positive in a number of test systems, it can be considered a potential human mutagen. Atrazine tested positive for mutagenicity in 15 of 33 assays. Technical oxyfluorfen and its contaminant PCE have in some instances tested positive for mutagenicity. EPA considers maneb to be mutagenic to mammals. Benomyl has tested positive for mutagenicity in some assays and negative in others. 2,4-D has questionable mutagenic potential. The worst-case risk of heritable mutations from atrazine, 2,4-D, oxyfluorfen, benomyl, maneb, 1,3-dichloropropene, methyl bromide + chloropicrin, dazomet (because of its soil breakdown product formaldehyde), and Vorlex should be at worst comparable to the risk calculated for cancer.

Worker Risk of Threshold Effects

Risks to workers are higher than those for the public both in routine operations and as a result of accidents. Workers have a much higher chance of being exposed than do members of the public and are likely to get higher doses than the public when they are exposed. As was the case for the public, workers are assumed to be at some level of risk if their exposures resulted in a margin of safety less than 100 for a particular pesticide.

Lifters are not at risk from any of the pesticides in routine-realistic exposures. The herbicides present a low to negligible risk to the other categories of workers for systemic and reproductive effects. Oxyfluorfen presents a low risk only to weeders and applicators. Atrazine and 2,4-D present risks only to applicators. Risks from the other herbicides are negligible under routine-realistic conditions. The fungicides, particularly chlorothalonil and maneb, present a higher (but still moderate) risk to weeders. Applicators are at negligible risk from the fungicides.

The insecticides present the highest risk to workers, especially weeders, in routine applications. Diazinon and chloropyrifos exposures, in particular, approach or exceed the systemic NOEL's. Cholinesterase inhibition symptoms are likely to occur, but there should be no severe irreversible effects. The risk from dimethoate is significantly less, and risks from carbaryl and fenvalerate are negligible.

Routine fumigant exposures to workers also present a risk. Methyl bromide exposures approach the systemic NOEL. Chloropicrin exposures exceed the NOEL and may cause some transitory toxic symptoms. However, the irritative properties of the chemical should prevent prolonged exposures.

In routine-extreme exposures, lifters are at risk only from the fungicides benomyl, chlorothalonil, and maneb. All of the fungicides present a moderate risk to the other worker categories, but the risk is generally less for applicators than for weeders or inventory personnel. Of the herbicides, oxyfluorfen presents the highest risks (the minimum MOS is 1) to the other worker categories, followed by diphenamid (the minimum MOS is 4). Among the insecticides, risks to applicators, weeders, and inventory personnel are low for carbaryl and insignificant for fenvalerate. Risks are greater (MOS of 6 or less) for the other insecticides.

Concentrate spill accidents present the greatest risk to workers. Worker exposures to dicamba, 2,4-D, metalaxyl, fenvalerate, and carbaryl approach the LD_{50}. The dimethoate dose equals the LD_{50}. For these pesticides, there is a clear risk of severe effects or fatality if the chemicals are allowed to remain on the worker's skin. Washing immediately should greatly reduce the risk. Accidental exposure from methyl bromide presents a similar risk for inhalation. The warning effect of chloropicrin in this fumigant mixture should reduce the risk.

Worker Risk of Nonthreshold Effects

Cancer risk to workers exposed for 5 years do not exceed 8 in 100,000 except for weeders exposed to maneb, who could have a risk of 8 in 10,000. Cancer risk from longer exposures would be proportionately greater. After 30 years of exposure, the risk from maneb exposure would be a maximum of 5 in 1,000. The maximum risk from exposure to the other chemicals would be 8 in 100,000.

The risk to workers of heritable mutations should be greater than those for the public, because workers are likely to be exposed more often and for longer periods of time. However, none of the pesticides has been proven to be more than weakly mutagenic, so the risk to workers should still be relatively low. The risks of heritable mutations should be at worst comparable to the cancer risks discussed above.

Chapter 1

Introduction

PURPOSE

The purpose of this analysis is to assess the risk to human health of using 28 different pesticides for the production of tree seedlings in the nurseries of the U.S. Department of Agriculture, Forest Service. Each nursery uses a number of different pesticides to suppress weeds, insects, fungi, and diseases that destroy seedlings or impair their growth. The analysis compiles the data and develops the methods necessary to analyze the use of pesticides in each individual Forest Service nursery. Risk calculations developed for a "generic" nursery for each pesticide are later applied to assess the risks of pesticide usage in the individual nurseries. (See appendix II.) The following 28 pesticides are examined in the risk assessment:

Herbicides

- Atrazine
- Bifenox
- 2,4-D
- DCPA
- Dicamba
- Diphenamid
- Glyphosate
- Napropamide
- Oxyfluorfen
- Sethoxydim
- Simazine

Fungicides

- Benomyl
- Captan
- Chlorothalonil
- DCNA
- Metalaxyl
- Maneb
- Thiram
- Triadimefon

Insecticides

- Carbaryl
- Chlorpyrifos
- Diazinon
- Dimethoate
- Fenvalerate

Fumigants

- Dazomet
- 1,3-Dichloropropene
- Methyl bromide + chloropicrin
- Vorlex

ORGANIZATION OF THIS REPORT

Chapter 1 presents the purpose, describes the structure, and outlines the methodology of the risk assessment. Chapter 2, the hazard analysis,

summarizes and discusses the toxic properties of each pesticide, including the cancer potency of the known or suspected carcinogenic pesticides. Chapter 3, the exposure analysis, outlines the nursery operations that use pesticides and the mitigation measures practiced in each, describes the methods used to estimate levels of exposure and resultant doses to workers and the public, and presents summary tables and discussions of estimated acute and long-term doses. Chapter 4, the risk analysis, presents the comparison of the results of the exposure analysis with the toxic effect levels set forth in chapter 2. Chapter 4 also discusses cancer risk based on estimated lifetime doses to workers and the public. Appendix I summarizes the fumigant worker exposure studies that were used to estimate nursery worker exposures in chapter 3. Appendix II contains individual risk assessments for each Forest Service nursery.

OVERVIEW OF THE RISK ASSESSMENT

This risk assessment examines the potential health effects on people who might be exposed to any of the 28 pesticides as a result of activities related to Forest Service nursery operations. People potentially at risk fall into two categories. The first group--workers--includes applicators and other personnel directly involved in the application of the pesticides as well as nursery personnel, such as crop inventory estimators, weeders, tree lifters, sorters, packers, and tree planters, who handle the tree seedlings at some time after the pesticide treatments. The second group--the public--includes nearby residents who could be exposed through the drift of pesticide spray droplets or vapors, by eating food items coated with pesticide residues, or by drinking water that contains such residues.

The risk assessment includes analyses of a range of possible exposures--from those that are most likely to occur to those that are extremely unlikely--resulting from pesticide application. A set of assumptions concerning the characteristics of typical pesticide applications and related nursery tasks ("routine-realistic") are used to estimate the doses to workers and to nearby members of the public that may reasonably be expected to occur as a result of routine pesticide application operations.

A second set of assumptions using extreme values of those application characteristics ("routine-extreme") are used to give higher dose estimates that are not likely to be exceeded except in the case of an accident. Assumptions about accidents are used to estimate doses to workers that may result from direct exposure to the spray mix or concentrate or from premature reentry into treated beds, and to nearby residents who may be downwind of an accidental spill of a fumigant.

Health risks are evaluated by comparing dose estimates for workers and the public with appropriate hazard levels as determined in tests on laboratory animals. For each pesticide, this analysis estimates both the risk of acute health effects (arising from a single exposure) and the risk of chronic health effects arising from a single exposure or from repeated exposures over various periods of time.

Structure of the Risk Assessment

Assessing the risk of effects on human health from the use of pesticides in Forest Service nurseries requires estimating what human exposures could occur as a result of pesticide applications and associated activities and estimating the probability and extent of adverse health effects as a result of those exposures. This risk assessment employs the three principal analytical elements described by the National Research Council (1983) as necessary to characterize the potential adverse health effects of human exposures to existing or introduced hazards in the environment: hazard analysis, exposure analysis, and risk analysis.

1. **Hazard Analysis** requires gathering information that is used to determine the toxic properties of each pesticide. Human hazard levels are derived primarily from the results of laboratory studies of animal models, such as rats, mice, and rabbits, supplemented where appropriate with information on human poisoning incidents, field studies of other organisms, and data on chemical structure.

2. **Exposure Analysis** involves estimating single and multiple exposures to persons potentially exposed to the pesticides, determining the doses likely to result from those estimated exposures, and determining the number and characteristics of persons in the exposed populations.

3. **Risk Analysis** requires comparing the hazard information with the dose estimates and the probability that they could occur to predict the health effects to individuals under the given conditions of exposure.

The relationships among these three components are illustrated in figure 1-1. This risk assessment identifies uncertainties, such as areas where scientific studies are unavailable, and describes how those uncertainties were dealt with to produce the results of the analyses. The discussion that follows briefly describes how each component in the structure was addressed in this risk assessment.

Hazard Analysis

The hazard involved in the use of each of the pesticides was determined from extensive literature searches summarized in background statements prepared on each pesticide for the Forest Service. In addition, all relevant data submitted to EPA in support of the registration of these pesticides that have been made available were reviewed. These background statements and studies were reviewed for required toxicity reference levels, in particular, rat oral LD_{50}'s (an LD_{50} is the amount of a substance will kill 50 percent of a laboratory test population), systemic and reproductive no-observed-effect levels (NOEL's), and data concerning cancer and mutagenicity. Where scientific uncertainty exists for a particular pesticide on a specific toxic effect, for example, mutagenicity, these areas are identified and a conclusion is drawn about the effect based on the available data. In particular, scientific uncertainty regarding

HAZARD ANALYSIS

- Identify what kinds of health effects have been observed in laboratory animals and at what levels of exposure
- Identify any health effects that have been observed in humans
- Determine median lethal dose (LD_{50}) for acute effects from laboratory rat study
- Determine lowest no-observed-effect levels (NOEL's), if possible, for general chronic toxic effects, reproductive effects, and birth defects
- Determine if the herbicide potentially causes cancer or mutations
- Identify data gaps in toxicity information

EXPOSURE ANALYSIS

- Identify people exposed
- Identify routes of exposure
- Estimate how much each person would receive by each exposure route using both routine and extreme case scenarios
- Estimate frequency and duration of exposure
- Calculate doses

RISK ANALYSIS

- Compare doses to NOEL's and LD_{50}'s and discuss probability of acute and chronic effects (including birth defects) for routine through worst case scenarios
- Conduct extreme case analysis for cancer risk
- Identify extreme case risk of mutations

Figure 1-1--Components of the risk assessment process

the results of the cancer studies on benomyl, captan, carbaryl, chlorothalonil, 2,4-D, 1,3 dichloropropene, dimethoate, fenvalerate, glyphosate, maneb, methyl bromide, and oxyfluorfen is discussed. Cancer potency values derived from laboratory animal tumor data are computed for the pesticides judged to be positive for cancer. The hazard analysis is presented in chapter 2.

Exposure Analysis

To assess the risks associated with the use of pesticides in Forest Service nurseries, it was necessary to document and analyze the use of pesticides in the nurseries. Major aspects of the nursery operations that determine potential levels of pesticide exposure were identified, including human activities in or near treated areas, application methods, application rates, the size and configuration of sprayed areas, and mitigation measures.

Two human populations are potentially affected by the use of pesticides in Forest Service nurseries. The first consists of the nursery workers who apply the pesticides (the mixers, loaders, and tractor drivers) and the nursery workers employed in tasks that bring them into direct contact with treated seedlings and soil (those who inventory the seedlings; weed the seedling beds; lift, sort, and pack the seedlings for shipment; and outplant the seedlings).

The second group at risk includes the population at large who live in the vicinity of the nursery and who may come into contact with the pesticides by offsite drift during application, contact with contaminated domestic animals, or consumption of contaminated water, vegetables, domestic animals, or wildlife. Impacts on wildlife are considered in this risk analysis only insofar as they affect human consumers and not as they affect the animal's health and survival.

In the exposure analysis, both realistic and extreme dose estimates are made for routine application operations. Doses from accidents are also estimated.

The determination of the exposure rate and the dosage of the populations at risk is based on several sources. Several studies investigating pesticide concentrations in urine samples of agricultural field workers were reviewed and their findings applied to this analysis. In some cases, exposure and dosage to the general population were extrapolated from worker data to analyze both realistic and extremely unlikely impacts. In other cases, dosage to the general public has been calculated based on realistic and extreme pesticide drift rates, dermal exposure and absorption rates, and food intake rates using realistic and unlikely assumptions concerning contamination levels.

Routine doses were estimated for the following:

- Mixer/loader/applicators
- Weeders, irrigators

- Inventory personnel
- Lifters, sorters, packers, and tree planters
- Fumigators
- Tarp lifters
- Seed treaters
- Root treaters

For the analysis of public health effects, dose estimates were made for nearby residents assumed to be exposed as a result of routine operations through one of the following routes:

- Eating a garden vegetable (lettuce) with drift residues
- Eating beef from cattle grazing in nearby pastures
- Eating a rabbit or grouse that has been dermally exposed in a treated seedling bed
- Drinking water with drift residues
- Drinking water from a source that receives runoff
- Direct dermal exposure from pesticide drift
- Petting a cat or dog with pesticide residues on its fur

For each of the above routes, two distances from the nursery were examined, 25 and 100 feet.

Because all human activities involve the possibility of error, the use of pesticides in nursery operations involves the possibility that humans may inadvertently receive unusually high exposures to the pesticides because of accidents. To examine what potential health effects could occur in an accident, the following accidental situations were analyzed:

- Spills of pesticide concentrate and mix on a worker's skin
- Direct accidental spraying of a worker
- Premature reentry of a worker into a treated area
- Inhalation exposure to workers or members of the public from a fumigant spill

Because the nurseries are fenced, access to the public is limited, and no aerial applications are done, the risk to the public from accidents is considered minimal.

Risk Analysis

Human health risks of the nursery operations were evaluated by comparing the doses of workers and the general public calculated for routine and accidental exposure scenarios to the laboratory-determined toxicity levels described in the hazard analysis.

The risks of threshold effects were evaluated in terms of a margin of safety (MOS), which is the ratio between the dose estimated in the exposure analysis and the NOEL. Risk increases as the estimated dose approaches the laboratory toxicity level; that is, as the MOS gets smaller.

The risk of a pesticide causing cancer was evaluated differently. It was assumed that a pesticide that causes cancer has some chance of causing it at any dosage level. Animal studies were used to determine how this risk changes with changes in exposure; then the laboratory data were adjusted to reflect the lower dose ranges, larger size, and longer lifespan of humans. The risk of cancer was calculated for various categories of people that may be exposed to the pesticides based on an estimated average daily exposure over a 70-year lifetime.

The risk of heritable mutations was based on available test data on bacteria, yeasts, plants, mammalian cells in culture, and whole animals, but it is not quantified as the risk of cancer was. Rather, a qualitative judgment is made concerning the potential for the pesticide to cause genetic mutations in humans at the dose levels liable to be experienced as a result of nursery applications, and, where appropriate, that risk is compared to the pesticide's cancer risk.

Cumulative risk for individuals is discussed in terms of lifetime exposures to a given pesticide for workers and for members of the public. Risk of synergistic effects is discussed in terms of the available evidence of enhanced toxicity in mixtures of two or more of the pesticides. Risk to sensitive individuals is discussed qualitatively in terms of the likelihood of a sensitive individual being exposed.

Chapter 2
Hazard Analysis

INTRODUCTION

This chapter presents the results of the hazard analysis--a review of available toxicological information on the 28 pesticides proposed for use in the Forest Service nursery program. The first section describes the sources of toxicity information used in the hazard analysis. The second section explains the terminology concerning laboratory toxicity testing, which is used later in describing the toxic properties of the pesticides. The third section presents summaries of the threshold toxicity of each pesticide drawn from the information that was available. The fourth and fifth sections describe the potential for each of the pesticides to cause the nonthreshold effects of genetic mutations and cancer, respectively. The final section presents the details of the derivation of cancer potency for those pesticides suspected of being carcinogenic.

SOURCES OF TOXICITY INFORMATION

The toxicities of atrazine, 2,4-D, dicamba, glyphosate, and simazine to both laboratory animals and humans are described in detail in the background statements prepared by the Forest Service as Agriculture Handbook 633 (USDA 1984a). Background statements outlining the toxicity and environmental fate of bifenox, DCNA, DCPA, dazomet, 1,3-dichloropropene, diphenamid, metalaxyl, napropamide, oxyfluorfen, sethoxydim, thiram, triadimefon, and Vorlex are detailed in Agricultural Handbook 670 (USDA 1987). Background statements on benomyl, captan, chlorothalonil, maneb, and methyl bromide + chloropicrin have been published as Agriculture Handbook 661 (USDA 1986b). Background statements on chlorpyrifos, dimethoate, and fenvalerate were prepared by Scientific Consulting Service for the Forest Service (USDA 1985b,c,d). The toxicity of carbaryl has been described in the Final Environmental Impact Statement: Gypsy Moth Suppression and Eradication Projects (USDA 1984b) and its supplements (USDA 1985a, 1986b). Toxicity information on diazinon was available in toxicology summaries prepared by the U.S. Environmental Protection Agency (1984g) and in the open literature.

Much of the data on pesticide toxicity have been generated to comply with the Federal Insecticide, Fungicide, and Rodenticide Act (FIFRA), as amended (7 U.S.C. 136 et seq.), which establishes procedures for the registration, classification, and regulation of all pesticides. EPA is responsible for implementing FIFRA. Toxicity levels and related information from the series of studies submitted for registration are compiled by EPA in summary tables called "tox one-liners" that are available on request from EPA's Freedom of Information Office. EPA has compiled "science chapters" on many of the pesticides and these are also available from EPA. A large body of additional toxicity information exists in the open literature, particularly for chemicals such as 2,4-D that have been used for many years.

An extensive literature search was funded by the U.S. Department of Agriculture, Forest Service, to ensure that all of the relevant available information was used in this risk analysis. A number of computerized literature retrieval data bases were searched to locate current literature pertaining to the carcinogenicity and mutagenicity of the herbicides; these data bases included Medline, the Embase (Excerpta Medica), Toxline, Hazardous Substance Data Bank (HSDB), Registry of Toxic Effects of Chemical Substances (RTECS), and the Chemical Carcinogenesis Research and Information System (CCRIS).

The data from the background statements were reviewed and compared with summaries of studies submitted to the Environmental Protection Agency for the registration of the 28 pesticides. Whenever possible, studies that have been reviewed and validated by EPA were used to set toxicity reference levels. No studies that were deemed invalid by EPA were used in the risk assessment.

HAZARD ANALYSIS TERMINOLOGY

Because of obvious limitations on the testing of chemicals on humans, most judgments about the potential hazards of pesticides to humans are necessarily based on the results of toxicity tests on laboratory animals. These toxicity test results are supplemented by information on actual human poisoning incidents and effects on human populations when they are available. The discussion of laboratory toxicity testing that follows is drawn primarily from Hayes (1982), Doull et al. (1980), and Loomis (1978).

Laboratory Toxicity Testing

Toxicity tests are designed to produce specific toxic endpoints, such as fatality or cancer, and toxicity reference levels, such as a no-observed-effect level (NOEL). In addition to the test animal used, toxicity tests vary according to test duration, route of administration, dose levels, dosing schedule, number of test groups, and number of animals per group.

Test Animal Species

Laboratory test animals function as models of the likely effects of the pesticide in humans. Ideally, the test animal should metabolize the compound the same as a human would and should have the same susceptible organ systems. Results of such tests could then be directly extrapolated to humans by adjusting for differences in body weight and body surface area (as related to metabolic rate). Although no test animal has proven ideal, a number of species have proven to be consistent indicators for certain types of toxicity tests, routes of administration, and types of chemicals; in particular, rats, mice, rabbits, hamsters, guinea pigs, dogs, and monkeys. Rats and mice are the most commonly used laboratory animals for toxicity testing. Rats are commonly used because of their low cost, relative ease of handling, documentation of genetic background, documentation of susceptibility to disease, and relatively short life span (2 to 3 years) (ENVIRON Corp. 1985).

Threshold and Nonthreshold Effects

Most chemicals are assumed to have a threshold level of toxic effects on a local basis (at the site of administration) or systemic basis (acting throughout the body), below which no adverse effects occur to the test organism. Chemicals are generally thought for regulatory purposes to have no such threshold level for cancer or mutations; rather, these toxic endpoints may occur (with a certain level of probability) even in the presence of extremely small quantities of the substance. In this hazard analysis, threshold effects are discussed first, followed by discussions of the nonthreshold effects, mutagenicity and cancer.

Duration of Toxicity Tests

The duration of toxicity tests ranges from very short-term acute tests through longer subchronic studies to chronic studies that may last nearly the lifetime of an animal. Acute toxicity studies involve administration of a single dose to each member of a test group (either at one time or in a cumulative series over a short period of less than 24 hours). Subchronic toxicity studies, which are used to determine the effects of multiple doses, usually last from a few days to 3 months but generally less than one-half the lifespan of the test animal. Chronic studies, also used to determine the effects of multiple or continuous doses, normally last 2 years but generally more than half the test species' lifespan. Nevertheless, studies that last 180 days or more are considered to be assessments of chronic toxicity.

Routes of Administration

Routes of administration include oral via gavage (forced into the stomach with a syringe through a plastic tube) or fed in the diet, dermal (applied to the skin), inhalation (through exposure to vapors or aerosol particles), and parenteral (injection other than into the intestine). Parenteral routes include subcutaneous (SC), which means injected under the skin; intraperitoneal (IP), injected into the abdominal cavity; and intravenous (IV), injected into a vein. Oral, dermal, and inhalation doses most nearly duplicate the likely routes of exposure to humans. Parenteral doses are used in testing drugs but are not widely used in toxicity testing of pesticides because they bypass the test animal's natural protective mechanisms.

Dose Levels

Doses are expressed in several ways. They can be expressed as milligrams of the chemical per kilogram of body weight of the test animal (mg/kg), or in parts per million (ppm) in the animal's diet, or in milligrams per liter (mg/l) in the air the animal breathes or in the water the animal drinks.

Dosing in long-term studies is generally done through the diet with specified amounts in parts per million in the food. The known weight of the test animals over the test period is used to convert parts per million in the diet to milligrams of chemical per kilogram of body weight per day

(mg/kg/day) for extrapolation to humans. Generally, at least three dose levels are used in addition to a zero dose or control group; 8 to 50 animals of each sex usually are dosed at each level.

Types of Toxicity Studies

Acute Toxicity Studies

Acute toxicity studies are used primarily to determine the toxicity reference level known as the median lethal dose (LD_{50}), which is the dose that kills 50 percent of the test animals. The lower the LD_{50}, the greater the toxicity of the chemical. The LD_{50} ranges and toxicity categories used in this risk assessment are those of the EPA classification system using rat LD_{50}'s, as shown in table 2-1 (adapted from Maxwell 1982, as cited in Walstad and Dost 1984). Because lethality is the intended toxic endpoint, dose levels usually are set relatively high in acute studies. Toxic symptoms displayed by the animals are recorded throughout the study, and tissues and organs are examined for abnormalities at the end of the test. The animal most commonly used for oral LD_{50}'s is the rat. Rabbits are used most often to determine dermal LD_{50}'s. For pesticides such as the fumigants, which can cause effects from inhalation exposure, an LC_{50} (median lethal concentration) is used for acute dose comparisons.

Because death represents the extreme toxic consequence for judging possible effects from the use of pesticides, the policies of regulating agencies regarding acceptable intake levels of these chemical compounds are not based on acute studies, but rather on toxicity tests designed to find the dose level that produces no effects in the animal species tested. Figure 2-1 illustrates the relationship between the LD_{50} and the no-effect level.

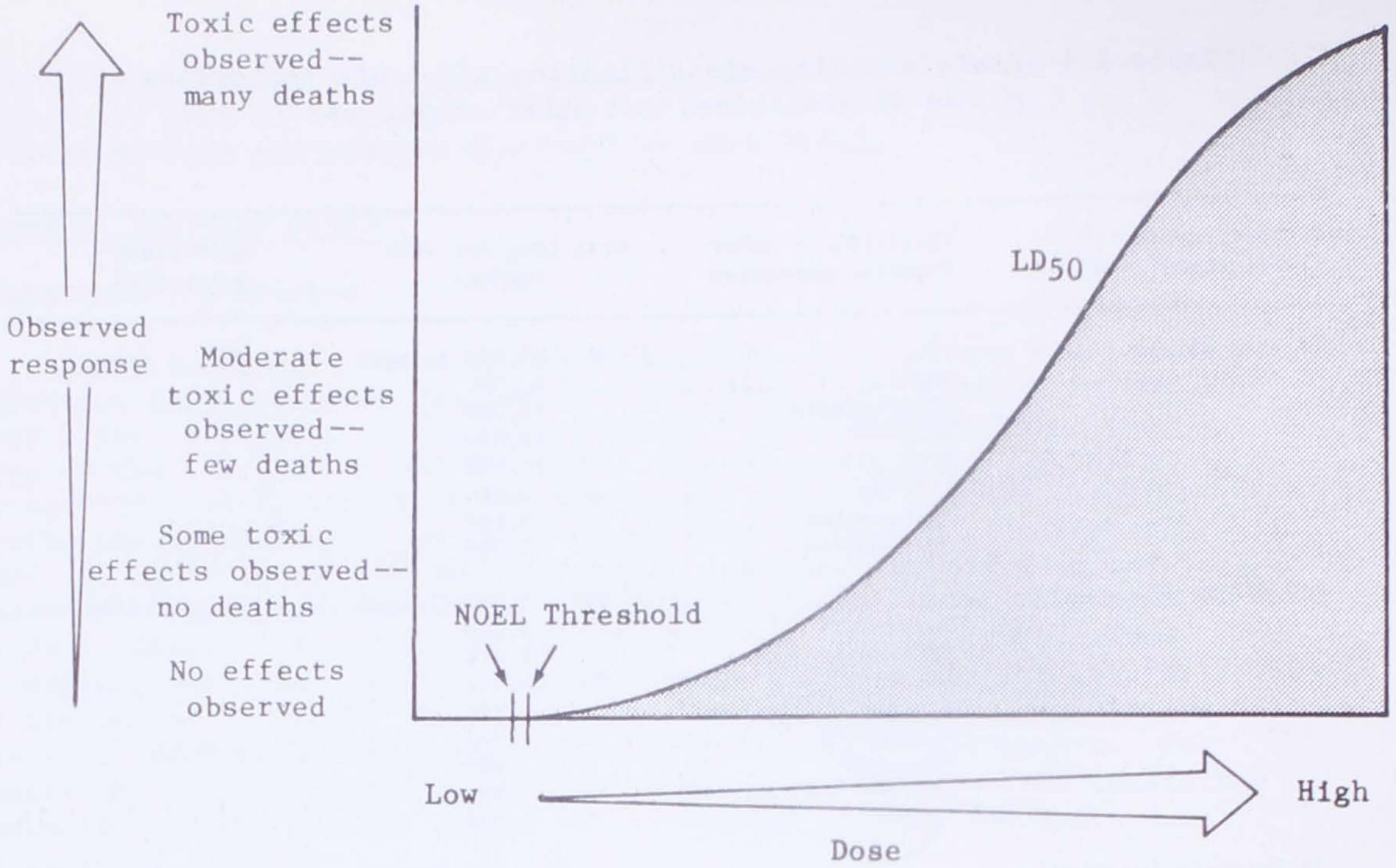
Subchronic Toxicity Studies

Subchronic studies are designed to determine the toxicity reference level called the no-observed-effect level (NOEL), which is the highest dose level at which no toxic effects are observed. If a chemical produces effects at the lowest dose tested (LDT) in a study, the NOEL must be at some lower dose. If the chemical produces no effects, even at the highest dose tested (HDT), the NOEL is equal to or greater than the HDT. Another toxic endpoint of interest is the lowest dose showing toxic effects--the lowest effect level (LEL). For local and systemic effects, the chemical's threshold of effect lies between the NOEL and LEL for the tested species (see figure 2-1). Subchronic studies, normally employing lower dose levels than acute studies, provide information on systemic effects, cumulative toxicity, the latency period (the time between exposure and the manifestation of a toxic effect), the reversibility of toxic effects, and appropriate dose ranges to be used in chronic tests. The adverse effects may include death; decreased rate of food consumption; change in body weight; decreased enzyme levels; changes in blood constituents, such as red blood cells or white blood cells; undesirable constituents in the urine; or microscopic changes in tissues.

Table 2-1--Acute toxicity classification and acute toxicities of the 28 pesticides and other chemicals

Toxicity category[a] (label signal words)	Pesticide or other chemical substance	Oral LD_{50} for rats (mg/kg)	Equivalent human dose
IV Very slight		5,000 - 50,000 (range)	More than 1 pint
	Sugar	30,000	
	Ethyl alcohol	13,700	
	DCPA	10,250	
	DCNA	10,000	
	Bifenox	6,400	
	Napropamide	5,000	
	Oxyfluorfen	5,000	
III Slight (caution)		500 - 5,000 (range)	1 ounce to 1 pint
	Table salt	3,750	
	Sethoxydim	2,676	
	Bleach	2,000	
	Aspirin, Vitamin B_3	1,700	
	Diphenamid	1,373	
	Metalaxyl	669	
	Thiram	620	
	Vorlex	538	
II Moderate (warning)		50 - 500 (range)	1 teaspoon to 1 ounce
	1,3-Dichloropropene	470	
	Triadimefon	363	
	Caffeine	200	
	DDT	100	
I Severe (danger-poison)		0 - 50 (range)	1 teaspoon or less
	Nicotine	50	
	Strychnine (rodenticide)	30	
	Parathion (insecticide)	13	
	TCDD (dioxin)	0.001	
	Botulinus Toxin	0.00001	

[a]Categories, signal words, and LD_{50} ranges are based on a classification system used by EPA for labeling pesticides.
Source: Maxwell 1982 (as cited in Walstad and Dost 1984).



LD_{50} - Acute lethal dose. One-time or short-term dose that is lethal to 50 percent of treated animals.

Threshold - Dose level at which toxic effects are first observed in test animals.

NOEL - No-observed-effect level. Long-term dose that does not result in apparent adverse effects in test animals.

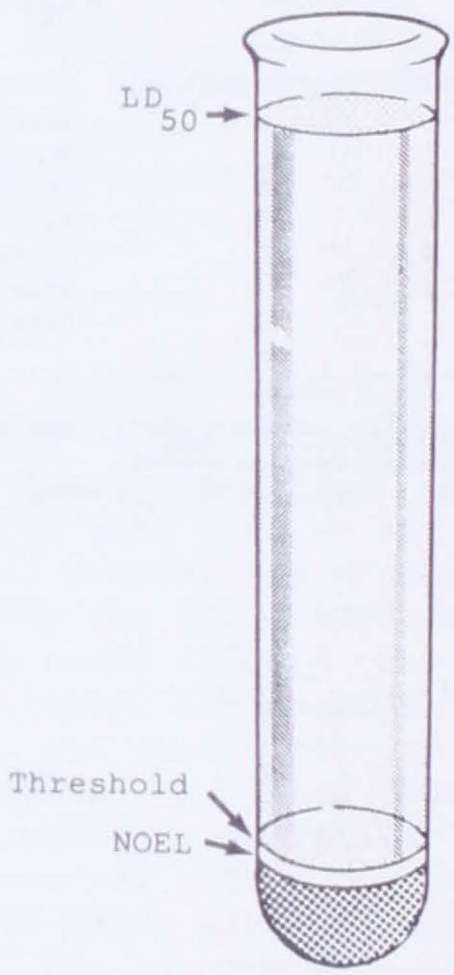


Figure 2-1--Relationships among toxicity reference levels

Chronic Toxicity Studies

Chronic studies, like subchronic studies, can be used to determine systemic NOEL's. All other things being equal, the longer the study from which the NOEL is derived, the more reliable the resulting value for estimating effects in humans. Chronic studies, however, are even more important in determining doses that are hazardous to reproductive success or in determining whether the chemical causes cancer. Tests for systemic effects, reproduction effects, and carcinogenicity provide the bulk of chronic data on laboratory animals.

Chronic feeding studies. Feeding experiments of more than 90 days are considered to be chronic studies. These tests can determine systemic NOEL's and define organ sites where long-term exposure can cause deleterious effects. Blood chemistry, hematology, histopathology, and gross pathology of the laboratory animals can provide detailed information on the effect of the pesticide during the animal's lifetime.

Teratogenicity tests. Teratogenicity tests (teratology studies) determine the potential of a chemical to cause malformations in an embryo or a developing fetus between the time of conception and birth. These studies generally use rats or rabbits, and, although usually short-term in nature, they may be conducted over several generations. The animals are monitored for functional as well as structural deformities.

Reproduction studies. Reproduction studies are conducted to determine the effect of the chemical on reproductive success as indicated by fertility (production of germ cells), fetotoxicity (direct toxicity to the developing fetus), maternal effects, and survival and weight of offspring. These tests are performed at doses similar to those used in teratogenicity studies and generally use rats. Both male and female rats are exposed to the chemical for a number of weeks before mating. The number of resulting pregnancies, stillbirths, and live births are recorded. Tests are usually conducted over two or three generations.

Cancer tests. Carcinogenicity tests (cancer studies or oncogenicity studies) examine the potential for a chemical to cause cancerous (malignant) or nonmalignant tumors when fed in the diet over the animal's lifetime. Testing is normally conducted with rats or mice for a 2-year period.

Mutagenicity Assays

Mutagenicity assays are used to determine the ability of a chemical to cause physical or chemical changes (mutations) in an organism's basic genetic material (DNA) that could be passed on from one generation to the next. The species used in these tests range from primitive organisms, such as the bacteria *Salmonella*, *Escherichia*, and *Streptomyces*; the mold *Aspergillus*; the yeast *Saccharomyces*; and the fruit fly *Drosophila*, to the more advanced organisms that include mammalian species. Tests may be conducted in vivo (within the body of the living organism) or in vitro (on cells cultured outside the body in a petri dish or test tube). There are many types of tests in this category, including the dominant lethal assay,

which is usually conducted with rodents, and the Ames reverse gene mutation test, which is conducted with bacteria. The section on the mutagenicity of the 28 pesticides gives more information about specific mutagenicity tests.

THRESHOLD TOXICITY OF THE 28 PESTICIDES

Acute and chronic threshold effect levels of the nursery herbicides, fungicides, and insecticides are presented in table 2-2. The nursery fumigants are discussed in a later section. The LD_{50}'s in table 2-2 are from rat acute oral toxicity studies. Rat studies were used because they are among the most commonly tested animals and values are available for all of the pesticides. (For more information on the use of rats in toxicity testing, see the section Test Animal Species.)

Two types of NOEL's are given in table 2-2. The first NOEL is for general systemic effects, such as growth retardation, decreased red blood cell count, and increased thyroid weight. A majority of the systemic NOEL's used in this risk analysis are taken from chronic feeding studies. Subchronic study NOEL's were used for bifenox, DCPA, diazinon, dicamba, metalaxyl, sethoxydim, napropamide, thiram, and vorlex because they are the lowest NOEL's found in the literature. Systemic NOEL's derived from studies with human volunteers are used for chlorpyrifos and dimethoate. These NOEL's are not the lowest reported values for chronic or subchronic studies; however, whenever possible, human data were used in this analysis.

The second type of NOEL listed is for reproductive effects, including infertility, miscarriage, general fetal toxicity, and birth defects (teratogenesis). Where information is available, NOEL's are given for both long-term exposure reproductive effects and short-term exposure teratogenic effects. All the NOEL's used are the lowest found in evaluated studies unless otherwise noted.

The following subsections summarize the most relevant acute and chronic toxicity tests that have been conducted on the 28 pesticides. Areas where no evaluated studies exist or in which EPA has requested additional studies are noted.

Herbicides

Atrazine

Atrazine can be classified as a slightly toxic herbicide, based on the acute oral LD_{50} of 1,869 mg/kg in rats (EPA 1984a). A 2-year dog feeding study resulted in the establishment of a systemic NOEL of 150 ppm (3.7 mg/kg/day) based on decreased body weight and reduced hemoglobin and hematocrit values (EPA 1984a). EPA has requested additional studies on the long-term effects of atrazine. A three-generation rat reproductive study reported no reproductive or systemic effects at the highest dose tested (100 ppm or 5 mg/kg/day) (EPA 1984a). No teratogenic effects were observed in test animals after rats were exposed to atrazine at up to 1,000 mg/kg/day (highest dose tested) (EPA 1984a). In the same study, fetotoxic and maternal toxic NOEL's of 100 mg/kg/day were established.

Table 2-2--Laboratory-determined toxicity levels used in the risk analysis

Pesticide	Acute oral LD_{50} in rats	Lowest systemic NOEL	Lowest reproductive and/or teratogenic NOEL
		Herbicides	
Atrazine	1,869 mg/kg (EPA 1984a)	150 ppm (3.7 mg/kg/day) 2-year dog feeding study (EPA 1984a)	Three-generation reproductive NOEL of >100 ppm (5.0 mg/kg/day) (HDT), rat (EPA 1984a) Fetotoxic and maternal toxic NOEL = 100 mg/kg/day, rat teratology study (EPA 1984a)
Bifenox	>6,400 mg/kg (WSSA 1983)	500 ppm (12.5 mg/kg/day) for 90-day dog feeding study (HDT) (WSSA 1983)	Three-generation reproductive NOEL of >200 ppm (10 mg/kg/day)(HDT), rat (unvalidated study; see USDA 1987)
2,4-D	375 mg/kg (EPA 1984d)	1.0 mg/kg, 1-year tentative NOEL for 2-year rat feeding study (EPA 1985e)	Fetotoxic and maternal toxic NOEL = 5 mg/kg/day, rat reproductive study (EPA 1986b)
DCPA	>3,160 mg/kg (EPA 1984f)	<1,000 ppm (50 mg/kg) (LDT), 30-day rat feeding study (EPA 1984f)	Reproductive NOEL <1,000 ppm (50 mg/kg/day) (LDT), 30-day rat feeding study (EPA 1984f)
Dicamba	757 mg/kg (USDA 1984a)	500 ppm (25 mg/kg/day) 90-day subchronic rat feeding study (EPA 1984h)	No teratogenic effects reported in 4 studies Fetotoxic and maternal NOEL = 3.0 mg/kg/day, rabbit teratology study (EPA 1984h) Reproductive NOEL = 2.5 mg/kg/day, rat (EPA 1985j); Note: Pilot study data not used to set NOEL
Diphenamid	1,373 mg/kg (EPA 1984i)	3 mg/kg/day, 2-year chronic feeding study of dogs (EPA 1984i)	Reproductive NOEL <30 mg/kg/day, fetotoxic NOEL = 10 mg/kg/day, three-generation rat reproduction study (EPA 1984i)
Glyphosate	4,320 mg/kg (EPA 1984j)	>30 mg/kg (HDT) 26-month rat feeding study (EPA 1984j)	Fetotoxic NOEL = 10 mg/kg, three-generation reproduction rat study (EPA 1984j)

Table 2-2--Laboratory-determined toxicity levels used in the risk analysis (continued)

Pesticide	Acute oral LD_{50} in rats	Lowest systemic NOEL	Lowest reproductive and/or teratogenic NOEL
		Herbicides (continued)	
			Maternal NOEL = 175 mg/kg, rabbit teratology study (EPA 1984j).
Napropamide	>5,000 mg/kg (EPA 19841)	25 mg/kg/day 91-day rat feeding study (EPA 19841)	Fetotoxic and maternal toxic NOEL = 10 mg/kg/day, rabbit teratology study (EPA 1985j) Teratogenic NOEL <25 mg/kg/day (LDT), rat teratology study (EPA 19841)
Oxyfluorfen	>5,000 mg/kg (EPA 1985c)	0.3 mg/kg/day 20-month mouse feeding study (EPA 1985c)	Fetotoxic NOEL = 0.5 mg/kg/day, three-generation rat reproduction study (EPA 1985c)
Sethoxydim	2,676 mg/kg female rats (EPA 1985d)	120 ppm (3 mg/kg/day) 26-week dog feeding study (EPA 1985d)	Teratogenic NOEL = 160 mg/kg/day, rabbit teratology study (EPA 1985d)
Simazine	>5,000 mg/kg (EPA 1984n)	>100 ppm (5 mg/kg/day) (HDT), 2-year rat feeding study (EPA 1984n)	>100 ppm (5 mg/kg/day) (ODT), three-generation reproduction study (EPA 1984n)
		Fungicides	
Benomyl	>10,000 mg/kg (EPA 1986a)	500 ppm (12.5 mg/kg/day) 2-year dog feeding study (EPA 1986a)	Fetotoxic NOEL = 30 mg/kg/day, teratogenic NOEL = 30 mg/kg/day, rat teratology studies (EPA 1984a) Reproductive NOEL = 100 ppm (5 mg/kg/day), rat three-generation reproduction study (EPA 1986a)
Captan	9,000 mg/kg (EPA 1985a)	25 mg/kg/day, 2-year rat feeding study (EPA 1985a)	Systemic NOEL = 12.5 mg/kg/day, one-generation and three-generation rat reproduction study (EPA 1985a) Teratogenic NOEL >400 mg/kg/day, hamster teratology study (EPA 1985a)
Chlorothalonil	>10,000 mg/kg (EPA 1984p)	1.5 mg/kg/day, 2-year dog feeding study (EPA 1984p)	Maternal toxic NOEL = 100 mg/kg/day, rat teratology study (EPA 1984p)

Table 2-2--Laboratory-determined toxicity levels used in the risk analysis (continued)

Pesticide	Acute oral LD_{50} in rats	Lowest systemic NOEL	Lowest reproductive and/or teratogenic NOEL
		Fungicides (continued)	
			Tentative fetotoxic NOEL = 5.0 mg/kg/day, rabbit teratology study (awaiting additional data; EPA 1984p)
DCNA	>10,000 mg/kg (EPA 1984e)	100 ppm (2.5 mg/kg/day) 2-year dog feeding study (EPA 1984e)	Fetotoxic and maternal toxic NOEL = 100 mg/kg/day, rat teratology study (EPA 1984e) Reproductive NOEL = 100 ppm (5.0 mg/kg/day), rat three-generation reproduction study (EPA 1984e)
Maneb	4,500 mg/kg (USDA 1986b)	2 mg/kg/day, 1-year dog feeding study (USDA 1986b)	Teratogenic NOEL 400 mg/kg/day (LDT) for rats (USDA 1986b) Reproductive NOEL = 5 mg/kg/day, 11 to 12-month rat reproduction study (USDA 1986b)
Metalaxyl	669 mg/kg (EPA 1985m)	250 ppm (6.25 mg/kg/day), 90-day and 6-month dog feeding studies (EPA 1985m)	Maternal and fetotoxic NOEL = 50 mg/kg/day in rat teratology study (EPA 1985m)
Thiram	560 mg/kg (Pennwalt 1986)	1.9 mg/kg/day, 30-day rat feeding study (Lowry, et al. 1980)	Reproductive NOEL = 2.4 mg/kg/day, three-generation rat reproduction study (Van Esch, as cited in Lowry et al. 1980) Teratogenic NOEL 31 mg/kg/day (LDT) for hamsters (Robens 1969, as cited in USDA 1987)
Triadimefon	363 mg/kg (EPA 1982a)	2.5 mg/kg/day, 2-year dog and rat feeding study (EPA 1982a)	Teratogenic NOEL = 50 mg/kg in rats (EPA 1982a) Fetotoxic NOEL = 50 ppm (2.5 mg/kg/day), reproductive and maternal toxic NOEL = 300 ppm (15 mg/kg/day), three-generation rat study (EPA 1982a)

Table 2-2--Laboratory-determined toxicity levels used in the risk analysis (continued)

Pesticide	Acute oral LD_{50} in rats	Lowest systemic NOEL	Lowest reproductive and/or teratogenic NOEL
		Insecticides	
Carbaryl	270 mg/kg (EPA 1984b)	200 ppm (10 mg/kg/day) 2-year rat feeding study (EPA 1984b); Note: effects in dogs not used to set NOEL	Reproductive NOEL = 25 mg/kg, three-generation rat reproduction study (EPA 1984b) Teratogenic NOEL = 3.125 mg/kg dog teratology study (USDA 1986a)
Chlorpyrifos	137 mg/kg (EPA 1985n)	0.03 mg/kg/day in 20-day human oral study (EPA 1984t) Note: effects in dogs not used to set NOEL	Reproductive NOEL >1.2 mg/kg in two-generation rat reproductive study (EPA 1985n) Maternal NOEL = 0.1 mg/kg in rat teratology study (EPA 1985n)
Diazinon	250 mg/kg (Gaines 1969)	0.020 mg/kg/day, 90-day dog feeding study (EPA 1984g)	Reproductive NOEL = 4 ppm (0.2 mg/kg/day) (EPA 1984g)
Dimethoate	250 mg/kg (EPA 1984u)	1 ppm (0.05 mg/kg/day) in a 2-year rat feeding study (EPA 1984u) 0.2 mg/kg/day in 39-day human study (EPA 1984w)	Reproductive NOEL >50 ppm (7.5 mg/kg) in a three-generation mouse study, but <9 mg/kg in a five-generation mouse study (EPA 1979)
Fenvalerate	1,000 to 3,000 mg/kg (EPA 1984v)	10 ppm (1.5 mg/kg) in male mice and 50 ppm (7.5 mg/kg) in female mice in a 24-month oncogenic study (EPA 1984v)	Reproductive NOEL = 250 ppm (12.5 mg/kg) in three-generation rat reproductive study (EPA 1984v) Teratogenic NOEL >50 mg/kg/day in mice and rabbits (EPA 1984v)
		Fumigants	
Chloropicrin	37.5 mg/kg (EPA 1984c)	5 mg/kg/day, 6-month rat feeding study (EPA, 1984c)	No data available
Dazomet	363 mg/kg (RTECS 1986a)	<0.5 mg/kg/day, 2-year rat feeding study (Gosselin et al. 1984, as cited in HSDB 1986a)	No NOEL's given; see text for discussion of reproductive effects of dazomet and its degradation products

Table 2-2--Laboratory-determined toxicity levels used in the risk analysis (continued)

Pesticide	Acute oral LD_{50} in rats	Lowest systemic NOEL	Lowest reproductive and/or teratogenic NOEL
		Fumigants (continued)	
1,3-Dichloropropene	470 mg/kg (EPA 1985b)	0.055 mg/l or 11.98 ppm, 90-day rat inhalation study (EPA 1985b) 1 ppm (0.0045 mg/l), 180-day inhalation study with rats, rabbits, guinea pigs, and dogs (Torkelson and Oyen 1977)	Maternal toxic NOEL = 20 ppm (0.6 mg/kg/day) (LDT), rabbit teratology inhalation study (EPA 1985h)
Methyl bromide	214 mg/kg (Danse et al. 1984)	16 ppm, 6-month inhalation study with dogs, rats, rabbits, guinea pigs, and monkeys (USDA 1986b) 75 mg/kg, 1-year dog feeding study (USDA 1986b)	Teratogenic NOEL >70 ppm (3.5 mg/kg/day in rats and 2.1 mg/kg in rabbits) (HDT), rat and rabbit teratology inhalation study (USDA 1986b)
Vorlex	538 mg/kg (EPA, 1984m)	<1 ppm (0.05 mg/kg) (LDT) 90-day rat inhalation study (EPA 1984m) 0.7 mg/kg/day, 3-month mouse feeding study with MITC (Schering AG 1983)	Fetotoxic NOEL = 1 mg/kg/day, maternal NOEL = 3 mg/kg/day, rabbit oral teratology study with MITC (Schering AG 1983)

Conversion factors: mouse, 1 ppm = 0.150 mg/kg/day; rat (lifetime), 1 ppm = 0.05 mg/kg/day; rabbit, 1 ppm = 0.030 mg/kg/day; dog, 1 ppm = 0.025 mg/kg/day.

Source: USDA 1984a.

Bifenox

Bifenox can be classified as a very slightly toxic herbicide, based on an acute LD_{50} of greater than 6,400 mg/kg (WSSA 1983). Laboratory testing of rats indicates that bifenox is rapidly metabolized and almost completely eliminated (90 percent) within 48 hours (EPA 1981a). The only subchronic studies available that have been accepted by EPA (Rhone-Poulenc 1984) are subchronic feeding studies of rats and dogs and a 21-day subacute dermal study on rabbits. No effects were observed in rats and dogs fed 500 ppm (approximately 25 mg/kg/day for rats and 12.5 mg/kg/day for dogs) for 90 days (WSSA 1983). In the rabbit study, at 113 mg/kg/day, no adverse systemic effects were noted (WSSA 1983). Rhone-Poulenc Inc. (1984) reports that a 2-year chronic dog-feeding study and a three-generation rat reproductive study have not been validated. The dog study showed no effects at doses up to 600 ppm (15 mg/kg/day), and a 52-week dog feeding study that is awaiting validation reported no effects at 1,000 ppm (25 mg/kg/day), the highest dose tested (Rhone-Poulenc 1986). No reproductive effects were found at doses up to 200 ppm (10 mg/kg/day) in the rat reproduction study.

2,4-D

2,4-D can be classified as moderately toxic in mammals with an LD_{50} in rats of 375 mg/kg (EPA 1984d). Clinical symptoms of 2,4-D intoxication have been observed in human case reports. Even though dermal absorption of 2,4-D is limited, the herbicide has been reported to produce peripheral neuropathy in a few individuals after accidental exposure. In several cases, the recovery has not been complete (USDA 1984a). A 2-year dog feeding study with dose levels of 2,4-D ranging from 0 to 500 ppm (0 to 12.5 mg/kg/day) established a systemic NOEL of 12.5 mg/kg/day (HDT) (EPA 1984d). The 1-year interim report for an oncogenic rat feeding study established a NOEL of 1 mg/kg/day for rats, based on toxic systemic effects in the kidneys of test animals (EPA 1985e). A second 2-year rat feeding study established a systemic NOEL of 1,250 ppm (62.5 mg/kg/day) (EPA 1984d). The systemic effects were observed in the kidneys of test animals.

Fetotoxic and maternal toxic NOEL's of 5 mg/kg/day are based on a study with rats exposed to 2,4-D acid at 5, 20, and 80 mg/kg/day. Decreased maternal body weight and reduced pup weight were observed at 20 mg/kg/day (EPA 1986b).

DCPA

DCPA can be classified as a slightly toxic herbicide, based on an acute LD_{50} of greater than 3,160 mg/kg in rats (EPA 1984f). A 28-day dog feeding study reported effects at 800 mg/kg/day, the only dose tested (EPA 1984f). This study has recently been invalidated by EPA (1986c) because of a low number of test animals and no controls. No toxic effects were observed in test animals as a result of a 90-day rat feeding study at 10,000 ppm (500 mg/kg) (HDT) (EPA 1984f). Chronic 2-year feeding studies using dogs and rats showed no effects at 10,000 ppm (HDT) (500 mg/kg/day for rats and 250 mg/kg/day for dogs) (EPA 1984f). No effects have been produced in a multigeneration reproductive study of rats exposed to 10,000

ppm (500 mg/kg/day) (EPA 1984f). A 30-day rat feeding study at doses of 1,000 ppm and 10,000 ppm determined systemic and reproductive NOEL's of less than 1,000 ppm (50 mg/kg/day) (EPA 1984f). No case of DCPA toxicity to a human has been reported. Human volunteers ingested up to 10,000 ppm without detectable effect and no appreciable storage of this material in body tissues has been demonstrated (Gosselin 1976). EPA was recently informed (April 1986) that the Dacthal® formulation of DCPA contains traces of the dioxin 2,3,7,8-TCDD in a concentration approximately 1/300 of that found in 2,4,5-T and silvex.

Dicamba

Based on an acute oral LD_{50} of 757 mg/kg in the rat, dicamba can be classified as slightly toxic (USDA 1984a). EPA reports a systemic NOEL value of 250 mg/kg/day (EPA 1985e). A number of subchronic rat studies did not find adverse effects at any of the doses tested (EPA 1984h). A 90-day subchronic feeding study in rats established a NOEL of 500 ppm (25 mg/kg/day) based on slight liver cell alterations (EPA 1984h). This NOEL is similar to one for mice that was used in a report by the Bonneville Power Administration (DOE 1983) and will be used in this risk analysis because it is conservative. In a 2-year rat study, a systemic NOEL of greater than 2,500 ppm (125 mg/kg body weight), the highest dose tested, was established (EPA 1986g). Fetotoxic and maternal toxic effects have been observed in laboratory animals exposed to dicamba. A fetotoxic NOEL of 0.5 mg/kg was reported for a rabbit teratology pilot study, with resorptions reported at 1.0 mg/kg (EPA 1984h). A second rabbit teratology study resulted in a maternal NOEL and a fetotoxic NOEL of 3.0 mg/kg (EPA 1984h). Recent information from EPA (1985j) has placed the reproductive NOEL of dicamba at 2.5 mg/kg.

Diphenamid

Diphenamid can be classified as slightly toxic, based on the acute oral LD_{50} of 1,373 mg/kg in rats (EPA 1984i). The systemic NOEL was 3 mg/kg/day in a 2-year feeding study of dogs, and a subchronic (72 days) feeding study of dogs resulted in a systemic NOEL of 10 mg/kg/day (EPA 1984i). A three-generation reproductive study of rats resulted in no reproductive effects at the highest level tested (30 mg/kg/day); however, a NOEL of 10 mg/kg/day was established based on fetotoxic effects (EPA 1984i). No study examining the teratogenic potential of diphenamid has been reported (EPA 1984i).

Glyphosate

Based on the acute oral LD_{50} of 4,320 mg/kg (EPA 1984j) in the rat, glyphosate can be classified as slightly toxic. A 26-month rat feeding study found no observable effects at the highest dose tested. Based on this study, EPA established a NOEL of 30 mg/kg/day (HDT) (EPA 1984j). A three-generation reproductive study of glyphosate in rats established a NOEL of 10 mg/kg/day (EPA 1984j). This NOEL was based on renal tubular dilation in the kidneys of the pups; no effects on fertility or

reproductive parameters were noted. Maternal NOEL's for two teratology studies in rats and rabbits were 1,000 mg/kg/day and 175 mg/kg/day, respectively (EPA 1984j).

Napropamide

Based on an LD_{50} of more than 5,000 mg/kg, napropamide can be classified as a very slightly toxic herbicide (EPA 19841). The lowest systemic NOEL reported for napropamide is 25 mg/kg/day, based on a 91-day rat feeding study (EPA 19841). Chronic 2-year feeding studies of both mice and rats yielded a systemic NOEL of 30 mg/kg/day (EPA 19841). This was also the level reported for the fetotoxic and maternal toxic NOEL's in a three-generation study of rats (EPA 19841). There were no teratogenic effects reported for valid teratology studies at the highest doses tested in two mammalian species (200 mg/kg/day, rabbit; and 400 mg/kg/day, rat) (EPA 19841). Maternal and fetotoxic NOEL's for a rabbit teratology study were both 10 mg/kg (EPA 1985k).

Oxyfluorfen

Based on an LD_{50} of greater than 5,000 mg/kg in rats, oxyfluorfen can be classified as a very slightly toxic herbicide (EPA 1985c). A 20-month oncogenic feeding study of mice reported a systemic NOEL of 2 ppm (0.3 mg/kg/day) based on histological abnormalities in the liver (EPA 1985c). Two teratogenic studies of oxyfluorfen have been reported: no teratogenic effects were observed in rats at 1,000 mg/kg/day or rabbits at 30 mg/kg/day (the highest levels tested) (EPA 1985c). A three-generation rat reproductive study reported a NOEL of 10 ppm (0.5 mg/kg/day) based on fetotoxic effects (EPA 1985c). Fetotoxic and maternal toxic NOEL's of 10 mg/kg/day were established from the rabbit teratology study (EPA 1985c).

Sethoxydim

Based on the acute oral LD_{50} of 2,676 for female rats, sethoxydim can be classified as a slightly toxic herbicide (EPA 1984m). The lowest systemic NOEL that has been reported for sethoxydim is 120 ppm, which was determined from a 26-week dog feeding study. The toxicity summary by EPA (1984m) records this dose level as equivalent to 7.5 mg/kg/day, but using a dietary conversion factor of 1 ppm = 0.025 mg/kg/day for dogs, a daily dose of 3 mg/kg is calculated; the lower dose will be used in this risk assessment. No reproductive effects were observed as a result of a two-generation rat reproductive study (EPA 1985d). A teratogenic NOEL of 160 mg/kg/day was reported for a rabbit teratology study (EPA 1985d).

Simazine

Based on the acute oral LD_{50} of greater than 5,000 mg/kg in the rat (EPA 1984n), simazine can be classified as very slightly toxic. A systemic NOEL greater than 100 ppm (5 mg/kg/day) (HDT) was reported for a 2-year rat feeding study (EPA 1984n). A 2-year dog feeding study did not find any overt signs of toxicity at 1,500 ppm (37.5 mg/kg/day) (HDT). EPA, however, has determined that chronic toxicity and oncogenic potential could not be determined from this study and additional studies have been requested. A

three-generation rat reproductive study established a NOEL greater than 100 ppm (5 mg/kg/day); there were no reported teratogenic, fetotoxic, or reproductive effects at the highest dose tested (EPA 1984n).

Fungicides

Benomyl

Based on an acute oral LD_{50} of greater than 10,000 mg/kg in rats (EPA 1986a), benomyl can be classified as very slightly toxic in mammals. A systemic NOEL of 500 ppm (12.5 mg/kg) was determined, based on the occurrence of irreversible toxic effects in both 2-year and 90-day feeding studies of dogs (EPA 1986a). A three-generation reproductive study of rats indicated that the reproductive NOEL for benomyl was 5 mg/kg/day (EPA 1986a). Rat teratology studies have determined NOEL's of 30 mg/kg/day in rats for fetotoxicity and 30 mg/kg/day for teratogenicity (EPA 1986a).

Captan

Based on an acute oral LD_{50} of 9,000 mg/kg in rats (EPA 1985a), captan can be classified as a very slightly toxic pesticide. The lowest systemic NOEL for captan is 25 mg/kg/day and was reported from a 2-year oncogenic rat feeding study (EPA 1985a). A three-generation and a one-generation reproductive study of rats resulted in a NOEL for fetal effects of 12.5 mg/kg/day (EPA 1985a). Based on a hamster teratogenic study, the teratogenic NOEL is greater than 400 mg/kg/day (EPA 1985a).

Chlorothalonil

Based on an acute oral LD_{50} of greater than 10,000 mg/kg in rats (EPA 1984p), chlorothalonil can be classified as very slightly toxic in mammals. The lowest systemic NOEL that has been found for chlorothalonil is 1.5 mg/kg/day, which was determined in a 2-year dog feeding study (EPA 1984p). A three-generation rat reproductive study did not result in reproductive effects at any level tested (EPA 1984p). A NOEL of 100 mg/kg/day was established from a rat teratology study (EPA 1984p). Maternal toxicity occurred at 400 mg/kg/day but teratogenic effects were not observed at any level tested. A tentative NOEL of 5 mg/kg/day was assigned to a rabbit teratology study pending individual data for the offspring (EPA 1984p).

DCNA

Based on an acute oral LD_{50} greater than 10,000 mg/kg in rats (EPA 1984e), DCNA can be classified as very slightly toxic in mammals. The lowest systemic NOEL that has been found for DCNA is 100 ppm (2.5 mg/kg/day), which was determined from a 2-year dog feeding study (EPA 1984e). Dogs fed DCNA at doses of 24 mg/kg/day and 48 mg/kg/day developed corneal and lens opacities after about 7 to 9 weeks on the diet. These effects were observed only in dogs that had been exposed to natural sunlight. At the next lowest dose, 6 mg/kg/day, no abnormalities of the eye were observed (Bernstein et al. 1970). A three-generation study of rats indicated that the reproductive NOEL for DCNA was 100 ppm

(5 mg/kg/day) (ODT) (EPA 1984e). There have been no teratogenic effects of DCNA observed in test animals in any teratology studies. A NOEL of 100 mg/kg/day, established from a teratology study, was based on fetotoxic and maternal toxic effects (EPA 1984e).

Maneb

Based on an acute oral LD_{50} of 4,500 mg/kg in rats (USDA 1986b), maneb can be classified as slightly toxic in mammals. The lowest systemic NOEL that has been found for maneb is 2 mg/kg/day, which was determined from a 1-year feeding study of dogs (USDA 1986b). A teratogenic NOEL of less than 400 mg/kg/day (LDT) was established from a rat teratology study based on fetal malformations (hydrocephaly, malformed spinal cord, malformed eyes, and dilated renal pelvis) (USDA 1986b). A rat reproductive study of 11 to 12 month's duration reported a NOEL of 5 mg/kg/day (USDA 1986b).

Metalaxyl

Metalaxyl can be classified as a slightly toxic fungicide, based on the acute oral LD_{50} of 669 mg/kg in rats (EPA 1985m). Ninety-day and 6-month dog feeding studies both established a systemic NOEL of 250 ppm (6.25 mg/kg/day) (EPA 1985m). A 90-day rat feeding study determined a systemic NOEL of 250 ppm (12.5 mg/kg/day), and a 2-year rat study determined a NOEL of 12.5 mg/kg/day (EPA 1985m). A three-generation rat reproductive study observed no effects at 1,250 ppm (62.5 mg/kg/day), which was the highest dose tested (EPA 1985m). No teratogenic effects were reported for the highest dose tested in rats (400 mg/kg/day) and rabbits (300 mg/kg/day) (EPA 1985m). However, maternal toxic NOEL's were established at 50 mg/kg/day for rats and 150 mg/kg/day for rabbits. In addition, a fetotoxic NOEL of 50 mg/kg/day was reported from the rat study. No fetotoxic or embryotoxic effects were observed in rabbits at the highest dose tested (300 mg/kg/day) (EPA 1985m).

Thiram

Based on an acute oral LD_{50} of 560 mg/kg in rats (Pennwalt 1986), thiram can be classified as slightly toxic in mammals. EPA (1984q) reported an acute oral LD_{50} of 620 mg/kg in rats. No subchronic or chronic studies with thiram have been accepted by EPA, but available open literature studies not specifically reviewed by EPA will be used as a "best source" of information to summarize the toxicity of thiram. Several invalidated studies have determined systemic NOEL's of 5 mg/kg/day (dogs), 6 mg/kg/day (female rats), and less than 5 mg/kg/day (male rats). A 30-day rat feeding study by Lowry et al. (1980) found systemic effects at the lowest dose tested (225 ppm or 11.3 mg/kg/day) and calculated a NOEL of 1.9 mg/kg/day using a log-probit model. A three-generation reproductive study defined a NOEL of 2.4 mg/kg/day for thiram fed to rats (Van Esch, as cited in Lowry et al. 1980). The lowest teratogenic NOEL found was less than 31 mg/kg (lowest dose tested) by gavage for a hamster study not specifically reviewed by EPA (Robens 1969, as cited in USDA 1987). Another teratology study was received by EPA in late 1985 and is being evaluated.

Triadimefon

Based on an acute oral LD_{50} of 363 mg/kg in rats (EPA 1982a), triadimefon can be classified as moderately toxic in mammals. The lowest systemic NOEL that has been reported for triadimefon is 2.5 mg/kg/day, which was determined as the systemic NOEL in both a 2-year dog feeding study and a 2-year rat feeding study (EPA 1982a). Teratogenic effects were observed in a rat teratology study, from which a teratogenic NOEL of 50 mg/kg/day was established based on cleft palate formation at 75 mg/kg/day (EPA 1982a). A three-generation rat reproductive study established a fetotoxic NOEL of 50 ppm (2.5 mg/kg/day), and maternal toxic and reproductive NOEL's of 300 ppm (15 mg/kg/day) (EPA 1982a).

Insecticides

Principal Toxic Effects of Organophosphates and Carbamates

This section summarizes a discussion by Murphy (in Doull et al. 1980) on the principal toxic effects of organophosphates and carbamates. The organophosphates (such as chlorpyrifos, diazinon, and dimethoate) and carbamates (such as carbaryl) both exhibit toxicity by inhibiting the activity of certain nerve transmission enzymes. These enzymes or cholinesterases (ChE's) include acetylcholinesterase (AChE) and function at nerve synapses to remove the choline (or acetylcholine) that conducts electrical impulses between nerve cells. The extent of inhibition of ChE caused by a given dose of insecticide is usually expressed as a percent; either a percent of normal activity or as a percent reduction compared to normal activity. The inhibition process is reversible. Organophosphates tend to inhibit ChE for longer periods than the carbamates at a given dose level, and the effects tend to accumulate, so that a sequence of low doses can produce the same effect as a single higher dose. Carbamates are relatively rapidly reversible ChE inhibitors. Organophosphates are generally metabolized in part to more active ChE inhibitors, for example, malathion to malaoxon; carbamates appear to function directly as inhibitors.

Toxic effects of ChE inhibition at low doses in humans include localized effects, such as nose bleed, blurred vision, and broncho-constriction; and systemic effects, such as nausea, sweating, dizziness, and muscular weakness. Effects of higher doses include irregular heartbeat, elevated blood pressure, cramps, and convulsions. In general, inhibition up to 40 percent (40-percent reduction in ChE activity) in laboratory animals and humans is tolerated well and may produce transitory, less severe symptoms. Inhibition above 50 percent can lead to much more severe, prolonged symptoms of ChE inhibition. Where a fatal dose of organophosphates or carbamates has been received without emergency treatment (generally by administering the antidote atropine), death usually occurs within 24 hours.

For the organophosphates, toxic effects other than ChE inhibition include delayed neurotoxic effects of phosphate triesters that include nerve cell demyelination and slow, but in general reversible, weakness and

flaccidity of the limbs. Organophosphates are tested for this specific type of delayed neurotoxicity using hens.

Carbaryl

Carbaryl can be classified as a moderately toxic carbamate insecticide, based on an acute oral LD_{50} of 270 mg/kg in rats (EPA 1984b). The lowest systemic NOEL that has been found was 1.8 mg/kg in a 1-year feeding study in dogs. For reasons not yet understood, dogs seem to be particularly sensitive to carbaryl. EPA has called for more data on how carbaryl affects dogs. The lowest systemic NOEL found in any other mammal was 200 ppm (10 mg/kg/day) (EPA 1984b) for a 2-year rat feeding study. This NOEL was used by EPA as the basis for setting carbaryl's acceptable daily intake (ADI) (USDA 1986a) and will be used as the systemic NOEL for this analysis. A three-generation study of rats established a reproductive NOEL of 25 mg/kg; at the dose level of 100 mg/kg, a decreased number of viable fetuses was observed. A teratologic NOEL of 3.125 mg/kg was reported for dogs, based on defects that included abdominal fissures, failure of skeletal formation, absence of tail formation, and the presence of extra toes (USDA 1986a). In addition to animal studies, the effects of carbaryl on humans have been documented in poisoning incidents, worker exposure studies, and volunteer ingestion studies. EPA has concluded that carbaryl will not cause birth defects in humans (EPA 1984w).

Chlorpyrifos

Chlorpyrifos can be classified as moderately toxic in mammals, based on an acute oral LD_{50} of 163 mg/kg for male rats and 137 mg/kg for female rats (EPA 1985n). Inhibition of AChE is the most sensitive endpoint for assessment of subchronic or chronic toxicity after exposure to chlorpyrifos. Acetylcholinesterase is essential to proper nerve function; it is an enzyme that inactivates the neurotransmitter chemical acetylcholine. If acetylcholine is not inactivated, it can accumulate in nerve tissue and effector organs, resulting in improper function of smooth and skeletal muscles, and central nervous system effects such as headache and anxiety. These effects, however, are reversible.

The ADI for chlorpyrifos of 0.003 mg/kg/day is currently based on a plasma AChE NOEL of 0.03 mg/kg/day that was derived from a 20-day study with human volunteers (EPA 1984t). A 2-year rat feeding study that determined a red-blood-cell ChE NOEL of 0.10 mg/kg/day was used to calculate the previous ADI (EPA 1984t). A plasma AChE NOEL of 0.01 mg/kg/day and a red-blood-cell NOEL of 0.10 mg/kg/day were derived from a 2-year dog feeding study (EPA 1985n). Although the duration of exposure was limited in the human study and the number of subjects was small, the policy of EPA is to use data from human studies in those cases where they are available and considered appropriate, as in this case where the human NOEL is in the range of NOEL's determined from animal studies. This risk assessment will use the NOEL derived from the human study to estimate the systemic effects of exposure to chlorpyrifos.

Diazinon

Based on an acute oral LD_{50} of 250 mg/kg for male rats and 285 mg/kg for female rats, diazinon (technical) can be classified as moderately toxic (Gaines 1969). The lowest systemic NOEL that has been found for diazinon is 0.02 mg/kg/day, which was determined from a 90-day dog feeding study based on plasma acetylcholinesterase inhibition (EPA 1984g). A multigeneration rat reproductive study resulted in a NOEL of 4 ppm (0.2 mg/kg/day) (EPA 1984g). A rabbit teratology study did not result in fetotoxic or teratogenic effects at 100 mg/kg/day (HDT); however, a maternal toxic NOEL of 25 mg/kg/day was reported (EPA 1984g). The ADI for diazinon has been set by EPA at 0.002 mg/kg/day.

Dimethoate

Dimethoate can be classified as a moderately toxic insecticide, based on the acute oral LD_{50} of 250 mg/kg in rats (EPA 1984u). Ninety-day feeding studies in dogs and rats established systemic NOEL's of 50 ppm (1.25 mg/kg/day) and 50 ppm (2.5 mg/kg/day), respectively (EPA 1984u). In laboratory animals, the lowest ChE inhibition NOEL's were reported at 2 ppm (0.05 mg/kg/day) in a 90-day dog feeding study and 1 ppm (0.05 mg/kg/day) in a 2-year rat feeding study (EPA 1984u). Red blood cell ChE depression was observed at 10 ppm (0.25 mg/kg/day) in dogs, and inhibition of plasma and brain ChE activities were observed at 20 ppm (0.5 mg/kg/day) in rats. The ChE NOEL in humans was established at 0.2 mg/kg/day for 39 days (EPA 1984u). A slow decrease in whole blood ChE activity was observed at 0.4 mg/kg/day for 57 days. A neurotoxicity study reported anticholinesterase toxic signs including weakness, unsteadiness, and dyspnea, but no signs of demyelination, at 20 to 30 mg/kg/day in hens (EPA 1984u). Other neurotoxicity studies reported no adverse nerve effects at 65, 130, or 260 ppm for 4 weeks in hens, although hens on 260 ppm lost 13 percent body weight; no paralysis resulted in hens when injected subcutaneously with dimethoate after they were given atropine orally to protect against acute poisoning (EPA 1984u).

No teratogenicity or adverse effects on reproduction were observed at the highest dose tested of 50 ppm (7.5 mg/kg/day) in a three-generation mouse reproductive study (EPA 1984u). However, reduced mating success, survival rate, and growth rate, and increased reproduction time and pup mortality were observed in a five-generation mouse reproduction study with 60 ppm (9 mg/kg/day) in drinking water (EPA 1979). An embryotoxicity study in mice reported preimplantation losses at 20 mg/kg and embryotoxicity at 40 mg/kg, but no teratogenicity (EPA 1979).

Fenvalerate

Based on the oral LD_{50} value of 1,000 to 3,000 mg/kg for the technical formulation of fenvalerate for rats, fenvalerate can be classified as a slightly toxic insecticide (EPA 1984v). The lowest systemic NOEL's reported were 10 ppm (1.5 mg/kg) in male mice and 50 ppm (7.5 mg/kg) in female mice based on evidence of multifocal granulomata in a 24-month oncogenic study (EPA 1984v). Systemic NOEL's less than 250 ppm (6.25 mg/kg/day) in a 6-month dog feeding study, and 125 ppm (6.25 mg/kg/day) in a 90-day rat feeding study were also reported (EPA 1984v).

Observed effects in the dog feeding study included emesis, headshaking, biting of the extremities, normocytic anemia, increased serum cholesterol levels, possible central nervous system and peripheral nerve dysfunction, and hepatic microgranule mitosis. Other chronic and subchronic NOEL's ranged from 12.5 to 25 mg/kg/day. The neurotoxic NOEL for fenvalerate was 12.5 mg/kg/day for 20 days in rats as a result of minimal clinical signs observed (EPA 1984v). However, no neurotoxic effects were observed at 1,000 mg/kg/day for 5 days in hens based on demyelination, and at 200 mg/kg in an 8-day rat study based on histopathological changes in peripheral nerves (EPA 1984v). Teratogenic and reproductive effects have not been observed in studies of mice, rabbits, and rats. A teratogenic NOEL greater than 50 mg/kg/day has been established in both mice and rabbits (EPA 1984v). A reproductive NOEL of 250 ppm (12.5 mg/kg/day) (HDT) was established in a three-generation rat reproduction study (EPA 1984v).

Fumigants

Table 2-3 provides inhalation toxicity information on the four fumigants used in nursery operations. Methyl bromide and chloropicrin are applied as a mixture but are treated as separate fumigants in this hazard analysis. The NOEL's listed were the lowest available values from inhalation exposure tests that were found in validated studies.

Dazomet

Based on the acute oral LD_{50} of 363 mg/kg in rats (RTECS 1986a), dazomet is classified as moderately toxic. Other oral LD_{50} values are 280 mg/kg for mice, 120 mg/kg for rabbits, and 160 mg/kg for guinea pigs (EPA 1985o). Toxic effects seen in acute testing include moderate congestion of the lungs, liver, and kidneys; opaque digestive tract membranes; convulsions; and reduced body temperature and activity (Smyth et al. 1966). In a primary dermal irritation study in rabbits, severe irritation was produced (EPA 1985o). The acute dermal LD_{50}'s in two rabbit studies were greater than 200 mg/kg and greater than 10,400 mg/kg. The rat acute inhalation LC_{50} was greater than 256 ppm for a 1-hour exposure (EPA 1985o).

Subchronic and chronic studies showed kidney and liver damage in rats and dogs. Rats fed 2,000 ppm for 30 days exhibited reduced food intake and growth, and increased kidney and liver weight in relation to body weight (Smyth et al. 1966). The systemic NOEL in a 2-year chronic rat study was reported as less than 0.5 mg/kg/day (Gosselin et al. 1984, as cited in HSDB 1986a). Cell death was noted in the kidney at 10 ppm (0.5 mg/kg/day) and in the liver at 40 ppm (2 mg/kg/day). No teratogenicity or reproduction studies have been reported for dazomet. Toxicity values for degradation products of dazomet are discussed below.

Methyl isothiocyanate (MITC). Methyl isothiocyanate (MITC) is a degradation product of dazomet. Based on the lowest oral LD_{50}'s of 72 mg/kg in female rats and 95 mg/kg in male rats (Schering AG 1983), MITC is moderately toxic. The acute inhalation LC_{50} for rats is 637 ppm for 1 hour. In a 3-month oral gavage study, the NOEL established for mice is less than 1 mg/kg/day and for rats is less than 2 mg/kg/day (Schering AG

Table 2-3--Inhalation toxicity reference values (in parts per million) for fumigants[a]

	Methyl bromide	1,3-Dichloropropene	Chloropicrin	Vorlex
LC_{50}	396 [a]	729 [b]	25.5 [c]	2.651 [d]
TC_{LO}	35 [e]	--	0.3 [f]	--
NOEL	16 [g]	1 [h]	--	<1 [i]
TLV	5 [j]	1 [k]	0.1 [l]	--

	Dazomet	MITC	Formaldehyde	Hydrogen sulfide	Monomethylamine
LC_{50}	<256 [m]	637 [n]	75 [o]	444 [p]	1,893 [q]
TC_{LO}	--	--	0.24 [r]	--	--
NOEL	--	10 [s]	--	--	--
TLV	--	--	1 [d]	10 [t]	10 [u]

Note: TC_{LO} = Lowest concentration resulting in a toxic effect. NOEL = Lowest NOEL found. TLV = Threshold limit value for humans, highest permitted concentration in an 8-hour period.

[a]Mouse (Bolander and Polyak 1962, as cited in USDA 1986b). [b]Rat, 4 hours (EPA 1985b). [c]Rat, 1 hour (Harton and Rawl 1976, as cited in EPA 1981c). [d]Rat, 1 hour (EPA 1984k). [e]Human, behavioral effects, gastrointestinal tract effects (NLM 1986a). [f]Human (NLM 1986b). [g]Rabbit, rat, guinea pig, monkey; 8 hours/day, 5 days/week for 6 months or more, tested at 16, 33, and 65 ppm (Irish et al. 1941, as cited in USDA 1986b). [h]Rat, 180 days (Torkelson and Oyen 1977). [i]Rat, 90 days, supplementary data (EPA 1984k). [j](ACGIH 1980, as cited in NLM 1986a). [k](NLM 1986c). [l](ACGIH 1982, as cited in NLM 1986b). [m]Rat, 1 hour (EPA 1985o). [n]Rat, 1 hour (Schering AG 1983). [o]Mammal, (RTECS 1986b). [p]Rat, (RTECS 1987b). [q]Mouse, 2 hours (RTECS 1987a). [r]Human, (RTECS 1986b). [s]Rat, 12-13 weeks (Schering AG 1983). [t]ACGIH 1986, as cited in RTECS 1987b). [u]ACGIH 1986, as cited in RTECS 1987a).

1983). The maximum safe dose in mice is 0.7 mg/kg/day. Subchronic effects include dermal and stomach lesions when administered orally or dermally. A 12 to 13 week inhalation study with doses of 1, 10, and 45 ppm showed toxic effects at high dose levels, but no histological changes. NOEL's established in a 2-year feeding study were 0.5 mg/kg/day in rats and 3 mg/kg/day in mice. Chronic effects included reduced body weight gain and reduced water consumption. A teratology study with rabbits given MITC orally from day 6 to day 18 of gestation determined a maternal toxic NOEL of 1 mg/kg/day and a fetotoxic NOEL of 3 mg/kg/day. An abnormal pattern of skeletal calcification was apparent in sacrificed embryos. In a three-generation rat reproductive study, no reproductive effects were seen at the highest dose tested of 10 mg/kg/day (Schering AG 1983).

Formaldehyde. Formaldehyde is a degradation product of dazomet. It is a slightly toxic chemical with an LD_{50} for rats of 800 mg/kg (RTECS 1986b; HSDB 1986b). In humans, formaldehyde is a skin and respiratory tract irritant, and a dermal sensitizer (IARC 1982). After sensitivity is induced, further exposure can elicit an allergic response. Effects of chronic exposure include respiratory impairment and dermatitis. No teratogenic effects or impairment of reproductive function have been reported for formaldehyde, although further studies are required for regulatory purposes (EPA 1986f).

Most people experience discomfort when exposed to 0.1 to 3 ppm formaldehyde in the air (EPA 1986f). Exposure to formaldehyde as an indoor fumigant in work areas is limited by EPA to 3 ppm (EPA 1986f). The Occupational Safety and Health Administration (OSHA) has also set a limit of 3 ppm as an 8-hour time-weighted average, but a level of 1.0 or 1.5 ppm was proposed in December 1985 (OSTP 1985). The threshold limit value specified by the American Conference of Governmental Industrial Hygienists (ACGIH) is 1 ppm, as a time-weighted average (RTECS 1986b; HSDB 1986b).

Inhalation studies in animals and epidemiological studies in workers have not demonstrated teratogenic effects (EPA 1986f). However, these studies were considered inadequate by EPA, and additional studies have been requested (EPA 1986f). A reproductive study showed prolonged diestrus but no impairment of reproductive function. This study was also considered inadequate by EPA, and a two-generation rat reproduction study has been requested.

Monomethylamine. Monomethylamine is also formed as dazomet degrades. Humans exposed briefly to 20 to 100 ppm of monomethylamine gas experience temporary eye, nose, and throat irritation; no symptoms of irritation are produced from longer exposures of less than 10 ppm (Clayton and Clayton 1982, as cited in HSDB 1986c). The OSHA standard for monomethylamine gas is 10 ppm for a time-weighted average (RTECS 1987a). The threshold limit value is also 10 ppm. The acute inhalation LC_{50} in mice is 1,893 ppm for 2 hours (RTECS 1987a). The lowest subcutaneous lethal dose is 200 mg/kg in rats and guinea pigs, 2,500 mg/kg in mice, and 2,000 mg/kg in frogs (HSDB 1986c).

Hydrogen Sulfide. Hydrogen sulfide is produced through the degradation of dazomet. Humans exposed to low doses of less than 50 ppm hydrogen sulfide experience irritation in the eyes, skin, and respiratory

tract (Rumack 1986, as cited in HSDB 1986d). The lowest lethal concentration of hydrogen sulfide gas reported for humans is 600 ppm for 30 minutes (RTECS 1987b). Death is caused by action on the nervous system resulting in respiratory paralysis (Doull and Amdur 1980). The inhalation LC_{50} in rats is 444 ppm and in mice is 673 ppm for 1 hour (RTECS 1987b). The lowest lethal concentration for guinea pigs is 0.719 ppm for 8 hours, and the lowest 5 minute lethal concentration found in mammals is 800 ppm (HSDB 1986d). The threshold limit value for hydrogen sulfide is 10 ppm (RTECS 1987b). The OSHA standard is 20 ppm with a peak of 50 ppm for 10 minutes. The recommended standard for occupational exposure is 11 ppm for 10 minutes (RTECS 1987b).

Carbon Disulfide. In the stomach, dazomet is broken down by metabolic activation to carbon disulfide. The lowest oral lethal dose of carbon disulfide reported for humans is 14 mg/kg (HSDB 1986e). Severe toxic effects have resulted from prolonged vapor exposures to concentrations as low as 0.1 mg/l (Gosselin 1976, as cited in HSDB 1986e). Chronic doses of carbon disulfide in humans result in motor disturbances, anemia, disturbances of cardiac rhythm, and increased urination. There is often degeneration in the liver and central nervous system, and fatty changes are found in the in the heart, liver, and kidneys (Thienes 1972, as cited in HSDB 1986e). In a subchronic inhalation study, rabbits showed slowing of nerve conduction velocity and clinical paralysis in the hind limbs (Seppalainen and Linnoila 1975).

1,3-Dichloropropene

Based on an acute oral LD_{50} of 470 mg/kg in female rats, 1,3-dichloropropene (Telone II) can be classified as moderately toxic. The oral LD_{50} for male rats was 713 mg/kg (EPA 1985b). A 4-hour inhalation study with rats determined an LC_{50} of 729 ppm (EPA 1985b). A 90-day inhalation study of rats resulted in a systemic NOEL of 0.055 mg/l or approximately 12 ppm (EPA 1985b). According to EPA (1985b), a 90-day feeding study using rats gave a NOEL of 3 mg/kg/day. A NOEL of 3 ppm (0.0135 mg/l) for female rats, rabbits, guinea pigs, and female dogs was established from a 180-day inhalation study (Torkelson and Oyen 1977). Due to compound-related, apparently reversible, slight histopathological changes in the liver and kidneys in male rats exposed to this dose, the authors concluded that 1 ppm (0.0045 mg/l) was a safe level of exposure. No teratogenic effects were reported in any teratology or reproductive study with 1,3-dichloropropene. Maternal toxic NOEL's of 20 ppm (0.6 mg/kg/day) for rabbits and less than 20 ppm (1 mg/kg/day) for rats were reported from teratology inhalation studies (EPA 1985h). Developmental toxicity (delayed ossification of vertebral centra) occurred in rats at the highest dose (120 ppm) (EPA 1986e). 1,3-Dichloropropene was not teratogenic in either species.

Methyl Bromide + Chloropicrin

Based on an acute oral LD_{50} of 37.5 mg/kg in rats (EPA 1984c), chloropicrin can be classified as severely toxic in mammals. Danse et al. (1984) estimated an acute oral LD_{50} for methyl bromide in rats of 214 mg/kg, which would classify this pesticide as moderately toxic. Acute

inhalation studies with mice resulted in a 1-hour LC_{50} of 1,164 ppm (4.5 mg/liter) for methyl bromide. A NOEL of 840 ppm (3.25 mg/1) was established (Alexeeff 1982, as cited in USDA 1986b). An LC_{50} of 396 ppm was reported in another mouse study for methyl bromide (Bolander and Polyak 1962, as cited in USDA 1986b). A 1-hour acute inhalation study with rats determined an LC_{50} of 25.5 ppm for chloropicrin (EPA 1981c).

Rabbits, rats, guinea pigs, and monkeys were exposed to 16, 33, or 65 ppm methyl bromide in the air for 8 hours daily, 5 days a week for periods of 6 months or more (Irish et al. 1941, as cited in USDA 1986b). It was reported that all species tolerated methyl bromide at 16 ppm. Teratogenic effects have not been observed in test animals after inhalation exposure to methyl bromide at the dose level of 70 ppm (3.5 mg/kg in rats and 21 mg/kg in rabbits) (USDA 1986b). A validated Industrial Bio-Test 6-month rat feeding study established a systemic NOEL of 100 ppm (5 mg/kg/day) for chloropicrin (EPA 1984c). There are no validated reproduction or teratology studies on chloropicrin reported by EPA (EPA 1981c).

Vorlex

Vorlex can be classified as a slightly toxic fumigant, based on the acute oral LD_{50} of 538 mg/kg in rats (EPA 1984k). Vorlex contains two active fungicidal and nematicidal chemicals--MITC and 1,3-dichloropropene--that are classified as moderately and slightly toxic, respectively. The only EPA-validated subchronic study with Vorlex is a 90-day rat inhalation study that established a NOEL of less than 1 ppm (0.05 mg/kg) (LDT) (EPA 1984k). No chronic feeding studies or mutagenicity assays on MITC have been reported by EPA (1984k) or in the open literature. A summary of studies conducted on MITC by Schering AG (1983) is included in the discussion of dazomet degradation products.

MUTAGENICITY OF THE 28 PESTICIDES

This subsection presents a review of the currently available information on the mutagenic hazard of the 28 pesticides. Mutagenicity assays may be divided into three categories: (1) tests for detecting gene mutations, (2) tests for detecting chromosomal aberrations, and (3) tests for detecting primary DNA damage. Included within the first group are microbial assays, involving prokaryotic (bacteria) and eukaryotic microorganisms, developed to detect reverse mutations and, to a limited extent, forward mutations. Bacterial tests may include a bioactivation system, such as S9-fraction consisting of microsomal enzymes of rats' or other animals' livers, to activate the mutagen. A host-mediated assay is conducted to detect mutagenic effects in a microorganism such as bacteria by injecting it into the peritoneal cavity of the host (usually mice) to allow for bioactivation of the mutagen in vivo. Other tests useful for predicting gene mutations are the fruit fly sex-linked recessive lethal test, which measures the frequency of lethal mutations; the mouse specific locus test, which detects mutagenicity in germ cells in vivo; and mammalian somatic cell in vitro assays, using mouse lymphoma cells, human lymphoblasts, and Chinese hamster lung cells to detect forward and reverse mutations.

Examples of tests for detecting chromosomal effects include mammalian cytogenetic assays in Chinese hamster ovary cells in vitro, and mice bone marrow micronucleus in vivo. The dominant lethal test in rodents, which determines toxic effects on germ cells, and the heritable translocation test in mice, which detects the heritability of chromosomal damages, are both important tests performed within live animals. Fruit flies and other insects are also used to detect heritable chromosomal effects in vivo.

The existence of DNA damage caused by mutagens is detected by biologic processes such as DNA repair and recombination that occur after DNA damage. Tests to determine such processes use bacteria, yeast, and mammalian cells in vitro, with or without metabolic activation. Unscheduled DNA synthesis, for example, is often used to indicate DNA repair in human cells in vitro. Mitotic recombination and gene conversion indicate DNA damage in yeast, and sister chromatid exchange indicates DNA damage in mouse lymphoma cells, Chinese hamster ovary cells, and human lymphocytes.

Although there are many types of tests available for detecting the mutagenic potential of chemicals, greater weight is placed on some. In general, for all three test categories, EPA (1984r) places greater emphasis on assays conducted in germ cells than in somatic cells, in vivo rather than in vitro, in eukaryotes rather than prokaryotes, and in mammalian species rather than submammalian species. EPA (1984r) classifies the evidence for potential human germ cell mutagenicity as sufficient, suggestive, or limited, depending on the results of various tests performed. For instance, positive results in at least one in vivo mammalian germ cell mutation test are considered sufficient evidence for potential human mutagenicity of a specific chemical.

Table 2-4 summarizes the tests reported for each of the 28 pesticides for each category of testing recommended by EPA in their guidance documents on mutagenicity (EPA 1978; EPA 1986d). Mutagenic assays that did not fall into any of the categories were not listed.

The majority of tests reviewed were those validated by EPA in tox one-liners or EPA science chapters. If tox one-liners or science chapters were not available, studies of mutagenicity were obtained from USDA pesticide background statements, which reported studies from the open literature. Tests reviewed for bifenox, diphenamid, thiram, and Vorlex were obtained from background statements (USDA 1987) that contained information gathered from confidential data and open literature due to a lack of other sources. Results reported within the same study for different test species or different test types were counted as individual tests; therefore, a single study reported in EPA tox one-liners may be represented more than once in table 2-4. For instance, one study that reported positive results in the Ames reverse mutation test for bacteria Salmonella and E. coli, both activated and inactivated, would represent four positive results in category 1A. Males and females, as well as different strains of the same species, were counted as one test only, unless different results were reported for each.

Table 2-4 also presents the relevance of the recommended tests to a determination of human mutagenic potential according to Dr. David Brusick,

Table 2-4--Mutagenicity testing on the 28 pesticides:
number of positive (+) and negative (-) assays

Mutagenicity test type[a]	Value in determining human mutagenicity[b]	Herbicides											
		Atrazine	Bifenox	2,4-D	DCPA	Dicamba	Diphenamid	Glyphosate	Napropamide	Oxyfluorfen	Sethoxydim	Simazine
Group 1--Tests for detecting gene mutations												
A Bacteria with and without metabolic activation	a	5(-)	2(-)	13(-)		6(-)	7(-)	6(-)	4(-)	3(+)1(-)	3(-)	12(-)
B Eukaryotic microorganisms with and without metabolic activation	a		1(-)	1(+)3(-)								
C Insects (e.g., sex-linked recessive lethal test)	ga			2(+)1(-)						1(+)1(-)		2(+)
D Mammalian somatic cells in culture with and without metabolic activation	ga											
E Mouse specific locus test in vivo	ga											
Group 2--Tests for detecting chromosomal aberrations												
A Cytogenetic tests in mammals in vivo	ga			3(-)				1(-)		2(-)		
B Insect tests for heritable chromosomal effects in vivo	ga											
C Dominant-lethal effects in rodents, heritable translocation tests in rodents, and in vitro cytogenetic assays in mammals	ga			2(+)3(-)	1(-)	1(-)		3(-)				
Group 3--Tests for detecting primary DNA damage												
A DNA repair in bacteria (including differential killing of DNA repair defective strains) with and without metabolic activation	na	3(-)		2(+)1(-)		2(+)1(-)	1(-)	1(-)	1(-)		1(-)	2(-)
B Unscheduled DNA repair synthesis in mammalian somatic cells in culture, with and without metabolic activation	na			1(+)3(-)		1(-)		2(-)		2(-)		2(-)
C Mitotic recombination and gene conversion in yeast, with and without metabolic activation	na			1(+)1(-)		2(-)						2(-)
D Sister-chromatid exchange in mammalian cells in culture, with and without metabolic activation	na			1(+)								

Table 2-4--Mutagenicity testing on the 28 pesticides: number of positive (+) and negative (-) assays (continued)

Mutagenicity test type[a]	Value in determining human mutagenicity[b]	Fungicides							
		Benomyl	Captan	Chlorothalonil	DCNA	Maneb	Metalaxyl	Thiram	Triadimefon
Group 1--Tests for detecting gene mutations									
A Bacteria with and without metabolic activation	a	1(+)6(-)		6(-)	2(-)	3(+)13(-)	1(-)	5(+)2(-)	3(-)
B Eukaryotic microorganisms with and without metabolic activation	a	1(+)				2(+)		1(+)	
C Insects (e.g., sex-linked recessive lethal test)	ga	1(+)				1(-)			
D Mammalian somatic cells in culture with and without metabolic activation	ga	1(+)		4(-)					
E Mouse specific locus test in vivo	ga		1(-)						
Group 2--Tests for detecting chromosomal aberrations									
A Cytogenetic tests in mammals in vivo	ga	2(+)1(-)	1(-)	6(-)		1(-)		2(+)1(-)	1(-)
B Insect tests for heritable chromosomal effects in vivo	ga					1(-)			
C Dominant-lethal effects in rodents, heritable translocation tests in rodents, and in vitro cytogenetic assays in mammals	ga	5(-)	1(+)2(-)	5(-)		2(+)	1(-)	3(+)1(-)	1(-)
Group 3--Tests for detecting primary DNA damage									
A DNA repair in bacteria (including differential killing of DNA repair defective strains) with and without metabolic activation	na			2(+)1(-)	1(-)			2(+)	2(-)
B Unscheduled DNA repair synthesis in mammalian somatic cells in culture, with and without metabolic activation	na	2(-)	2(-)			2(-)		1(+)	
C Mitotic recombination and gene conversion in yeast, with and without metabolic activation	na					1(+)1(-)		1(+)	
D Sister-chromatid exchange in mammalian cells in culture, with and without metabolic activation	na	2(+)		1(-)					

Table 2-4--Mutagenicity testing on the 28 pesticides: number of positive (+) and negative (-) assays (continued)

Mutagenicity test type[a]	Value in determining human mutagenicity[b]	Fumigants and Insecticides									
		Chloropicrin	Dazomet	1,3-Dichloropropene	Methyl bromide	Vorlex	Carbaryl	Chlorpyrifos	Diazinon	Dimethoate	Fenvalerate
Group 1--Tests for detecting gene mutations											
A Bacteria with and without metabolic activation	a	1(+)		2(+)	3(+)	6(-)[c]			1(-)	4(+)6(-)	2(-)
B Eukaryotic microorganisms with and without metabolic activation	a										
C Insects (e.g., sex-linked recessive lethal test)	ga	1(-)	1(-)		1(+)						
D Mammalian somatic cells in culture with and without metabolic activation	ga				1(+)						
E Mouse specific locus test in vivo	ga										
Group 2--Tests for detecting chromosomal aberrations											
A Cytogenetic tests in mammals in vivo	ga		1(+)1(-)					1(-)			
B Insect tests for heritable chromosomal effects in vivo	ga									1(+)	1(-)
C Dominant-lethal effects in rodents, heritable translocation tests in rodents, and in vitro cytogenetic assays in mammals	ga						1(-)[d]	2(-)			1(-)
Group 3--Tests for detecting primary DNA damage											
A DNA repair in bacteria (including differential killing of DNA repair defective strains) with and without metabolic activation	na			1(+)		1(-)[c]		2(+)			
B Unscheduled DNA repair synthesis in mammalian somatic cells in culture, with and without metabolic activation	na				1(-)						
C Mitotic recombination and gene conversion in yeast, with and without metabolic activation	na							2(+)		1(+)	
D Sister-chromatid exchange in mammalian cells in culture, with and without metabolic activation	na		1(+)		1(-)						

[a]Source: FIFRA, Environmental Protection Agency (EPA 1978).
[b]Value in Determining Human Mutagenicity (USDA 1985): a = applicable; ga = greater applicability; na = not applicable.

Sources: EPA toxicological summaries for individual pesticides 1982-1986 were used to prepare this table unless otherwise noted; USDA background reports on maneb, methyl bromide, and chlorpicrin (USDA 1986b); USDA 1984a for 2,4-D, dicamba, and simazine; USDA (1987) reports on bifenox, diphenamid, DCNA, thiram, and Vorlex. Atrazine studies listed are only those described in EPA 1984a.

a recognized expert in the field of mutagenicity testing.[1] In general, the most reliable mutagenic assays are in vivo cell studies and germ cell or gonadal studies (for example, Drosophila fruit fly sex-linked recessive studies). A germ cell study is considered relevant to evaluating the mutagenicity of a chemical even if the test organism is not mammalian. In vitro studies using mammalian cells are less useful because of the high percentage of false positive findings induced by interactions between the cultured cells and media conditions. Tests for detecting primary DNA damage (group 3 in table 2-4) are not useful in determining the human mutagenic potential of a chemical.

An overview of the mutagenicity test results is given in table 2-5. For some of the herbicides, no validated mutagenicity tests exist or the mutagenicity tests conducted are insufficient to conclude whether the chemical is mutagenic. For these herbicides, the worst case analysis presented in chapter 4 assumed that these herbicides are mutagenic. In these cases, the results of carcinogenicity tests (table 2-5) were used to estimate mutagenic risk, based on a high correlation between mutagenic and carcinogenic activity reported in several studies (Blackburn et al. 1984; Pogodina et al. 1984; Parodi et al. 1981, 1982, 1983a,b). The correlation between chemical carcinogenicity and mutagenicity as shown in assays varies greatly according to the class of chemicals and the types of tests used. Carcinogenicity tests should not be viewed as definitive predictors but rather as possible indicators of mutagenicity.

Herbicides

Atrazine

Mutagenicity assays on atrazine that were evaluated and accepted by EPA (1984a) were all negative. Five bacterial reversion assays, one of which was activated with S9, and three recombination assays with bacteria found no mutagenic response with atrazine. Studies not evaluated by EPA include positive responses in gene mutation assays, chromosome alterations in germ cells, and chromosome observations in bone marrow cells of rodents (USDA 1984a). Positive responses in these types of assays indicate a potential for mutagenic hazard. However, the in vivo responses in bone marrow cells were observed only at very high levels of atrazine equal to or exceeding 1,500 mg/kg (USDA 1984a). Although these results show that atrazine must be viewed as mutagenic at high levels of exposure, it appears that the degree of hazard to humans from low levels of exposure would likely be minimal.

Bifenox

Mutagenicity tests on bifenox conducted by Industrial Bio-Test Laboratories were judged invalid by EPA (1981a). Studies reviewed by the EPA that were not sufficient to meet data requirements but provided some

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Table 2-5--Summary of mutagenicity and carcinogenicity of pesticides

Pesticide	Mutagenicity	Carcinogenicity
	Herbicides	
Atrazine[a]	Mutagenic in 19/38 assays (USDA 1984a); nonmutagenic in 8/8 assays (EPA 1984a)	Oncogenic in 1/3 studies (EPA 1984a; EPA 1986c)
Bifenox	Nonmutagenic in 3/3 assays (USDA 1987)	Nononcogenic in 3 studies (Rhone-Poulenc 1986); studies are not validated or are awaiting validation
2,4-D[a]	Nonmutagenic in 28/38 assays (USDA 1984a)	Oncogenic in 1/3 studies (EPA 1984d; EPA 1986b)
DCPA	Nonmutagenic in 1 assay (EPA 1984f)	Nononcogenic in 2 studies (EPA 1984f); HCB contaminant is oncogenic
Dicamba	Mutagenic in 2/13 assays (USDA 1984a)	Nononcogenic in 2 studies (EPA 1984h); studies not adequate, according to EPA (19851); nononcogenic in 1 study (EPA 1986g)
Diphenamid	Nonmutagenic in 8/8 assays (Open literature studies listed in USDA 1987)	Nononcogenic in 1 study (EPA 1984i)
Glyphosate[a]	Nonmutagenic in 13/13 assays (EPA 1984j)	Nononcogenic in 1 study at HDT (EPA 1984j); possibility of weak oncogenic effect in mouse study (EPA 1985i); scientific uncertainty (EPA 1986c)
Napropamide	Nonmutagenic in 5/5 assays (EPA 19841)	Nononcogenic in 2 studies (EPA 19841)
Oxyfluorfen[a]	Technical oxyfluorfen and GOAL formulation nonmutagenic in 8/11 assays, PCE contaminant non-mutagenic in 4/8 assays (EPA 1985c)	Nononcogenic in 3 chronic studies (EPA 1985c); PCE contaminant was oncogenic in 4/8 studies (EPA 1981b; USDA 1987)

Table 2-5--Summary of mutagenicity and carcinogenicity of pesticides (continued)

Pesticide	Mutagenicity	Carcinogenicity
Sethoxydim	Nonmutagenic in 4/4 assays (EPA 1985d)	Nononcogenic in 2 studies (EPA 1985d)
Simazine	Mutagenic in 2/20 studies (USDA 1984a)	Oncogenic potential undetermined in 1 study (EPA 1984n)
	Fungicides	
Benomyl[a]	Mutagenic in 8/22 assays (EPA 1986a)	Oncogenic in 2/4 studies (EPA 1985f; USDA 1986b)
Captan[a]	Mutagenic in 1/7 assays (EPA 1985a)	Oncogenic in 5/8 studies (USDA 1986b)
Chlorothalonil[a]	Mutagenic in 2/25 assays (EPA 1984p)	Oncogenic in 1/3 studies (USDA 1986b)
DCNA	Nonmutagenic in 3/3 assays (USDA 1987)	Nononcogenic in 2 studies (EPA 1984e)
Maneb[a]	Mutagenic in 8/27 assays (USDA 1986b)	Oncogenic in 3/6 studies (USDA 1986b)
Metalaxyl	Nonmutagenic in 2/2 assays (EPA 1985m)	Nononcogenic in 2 studies (EPA 1985m)
Thiram	Mutagenic in 15/19 assays (Open literature studies, see USDA 1987)	Nononcogenic in 3 studies (Open literature studies, see USDA 1987)
Triadimefon	Nonmutagenic in 7/7 assays (EPA 1982a)	Nononcogenic in 3 studies (EPA 1982a)
	Insecticides	
Carbaryl[a]	Mutagenic in 6/7 assays accepted by EPA (1984b)	Nononcogenic in 6 studies (USDA 1985a)
Chlorpyrifos	Mutagenic in 4/7 assays (EPA 1985n)	Nononcogenic in 2 studies (EPA 1985n)

Table 2-5--Summary of mutagenicity and carcinogenicity of pesticides (continued)

Pesticides	Mutagenicity	Carcinogenicity
Diazinon	Nonmutagenic in 1 study (Shirasu et al. 1977)	Nononcogenic in 4 studies (EPA 1984g)
Dimethoate	Mutagenic in 6/12 assays (EPA 1984u)	Oncogenic in 2/4 studies (EPA 1984u)
Fenvalerate	Nonmutagenic in 4/4 assays (EPA 1984v)	Oncogenic in 1/4 studies (EPA 1984v)
	Fumigants	
Chloropicrin	Mutagenic in 1/2 assays (USDA 1986b)	Nononcogenic in 2 studies (USDA 1986b)
Dazomet[a,b]	Mutagenic in 2/4 assays (EPA 1985o)	Nononcogenic in 1 study (Gosselin et al. 1984, as cited in HSDB 1986a); formaldehyde breakdown product oncogenic (EPA 1986f)
1,3-Dichloropropene[a]	Mutagenic in 3/3 assays (EPA 1985h)	Oncogenic in 3/3 studies (EPA 1985h; USDA 1987)
Methyl bromide	Mutagenic in 5/7 assays (USDA 1986b)	Oncogenic in 1 study (USDA 1986b)
Vorlex (MITC)[a]	Nonmutagenic in 7/7 assays (Schering 1983	Nononcogenic in 2 studies (Schering 1983); 1,3-Dichloropropene component of Vorlex was oncogenic in 3 studies (EPA 1985h; USDA 1987)

[a]The risk of cancer of this pesticide is quantified in the risk analysis.
[b]See text for discussion of mutagenicity and oncogenicity of dazomet degradation products.

qualitative information revealed no adverse effects of regulatory concern. Three recent mutagenicity studies not reviewed by EPA yielded negative results with bacteria and yeast assays (USDA 1987). Thus, there is no evidence at this time to indicate that bifenox is mutagenic.

2,4-D

No mutagenicity studies were reported on the most current EPA tox one-liner for 2,4-D (EPA 1984d). Studies not evaluated by EPA have determined negative, weakly positive, and positive mutagenic responses to 2,4-D exposure for various test systems (USDA 1984a). Mutagenic assays with 2,4-D have yielded conflicting results in gene mutation tests with eukaryotic organisms and insects, in chromosomal aberration tests with mammals, or mammalian cells, and in primary DNA damage tests in prokaryotic, eukaryotic, and mammalian organisms. Positive results were found in one assay and negative results were also recorded for the same type of test in another assay. Tests of 2,4-D for gene mutation in bacteria were all negative. Newton and Dost (1981) concluded that 2,4-D may be a weak mutagen but that it is "without significance as an environmental mutagenic hazard." EPA has requested additional data to evaluate the mutagenic potential of 2,4-D in mammalian test systems. Thus, the current evidence appears to indicate that 2,4-D may be weakly mutagenic.

DCPA

A dominant lethal assay of DCPA on Sprague-Dawley rats tested negative for mutagenic effects (EPA 1984f). A medium containing DCPA was fed to Oregon-R wild-type fruit flies (Drosophila melanogaster) and induced no mutations (Paradi and Lovenyak 1981, as cited in USDA 1987). Although judged to be incomplete or inadequate by EPA (1984f), two bacterial Ames tests and an in vivo cytogenetic study revealed negative mutagenic results. Thus, there is no evidence at this time to suggest that DCPA is mutagenic.

Dicamba

Mutagenicity tests for dicamba were reviewed but not classified by EPA (1984h). USDA (1984a) reported dicamba as nonmutagenic in 11 of 13 tests. Six bacterial point mutation assays, a dominant lethal mouse assay, and four DNA damage assays were negative, while two bacterial tests for DNA damage were positive. Current evidence therefore indicates that dicamba is not mutagenic.

Diphenamid

No mutagenicity studies were reported by EPA (1984i) in the diphenamid tox one-liner. All eight mutagenicity tests reported from a review of the open literature (USDA 1987) were negative. Seven bacterial tests with and without metabolic activation showed negative results for point gene mutation, and one bacterial test reported negative results for DNA repair. There is therefore no evidence to suggest that diphenamid is mutagenic.

Glyphosate

Glyphosate was not mutagenic in microbial assays for gene mutation and primary DNA damage, and it was also not mutagenic in mammalian cell assay systems both in vitro and in vivo (EPA 1984j). There is no evidence to indicate that it is mutagenic.

Napropamide

Five bacterial mutagenicity tests evaluated and accepted by EPA (19841) had negative results for point mutation and primary DNA damage. Stauffer Chemical Company (1984) conducted various mutagenicity tests that were not evaluated by the EPA but that do corroborate the negative results. Chromosome aberration testing in mouse lymphoma cells, a mouse micronucleus test, a human fibroblast DNA test, and a microbial assay using four strains of the same bacteria were all negative. One multiple endpoint test on mouse lymphoma gave a positive result. The bulk of testing suggests that napropamide is not mutagenic.

Oxyfluorfen

Mutagenicity assays have been performed with technical oxyfluorfen (analytical GOAL of approximately 99 percent pure oxyflurfen), with technical GOAL (designated as RH 2915 of approximately 72 percent oxyfluorfen purity), and with the polar fraction of technical GOAL.

The polar fraction contains concentrated quantities of the impurities found in technical GOAL that are believed to influence the mutagenic response observed in positive assays with technical GOAL (EPA 1981b). According to EPA (1985c), a bacterial Ames test, a rat cytogenicity assay, and a bacterial host-mediated assay with technical oxyfluorfen were negative for mutagenicity. An assay using mouse lymphoma cells dosed with analytical GOAL was negative. Technical GOAL was mutagenic in a forward mutation assay with mouse lymphoma cells but produced no mutagenic effects in a rat-cytogenicity assay. Positive results were determined in one of two Salmonella microsome assays with technical GOAL. The polar fraction of technical GOAL produced positive results in the same Salmonella assay, both with and without S9 activation. Assays for unscheduled DNA synthesis with technical GOAL and its polar fraction were both negative.

Perchloroethylene (PCE) is a contaminant of technical GOAL (72 percent pure oxyfluorfen) and must be considered in evaluating the mutagenic potential of oxyfluorfen. Bacterial assays of PCE gave positive results in four out of eight tests (EPA 1981b). One of the studies compared purified and technical PCE and determined that the latter caused point mutations in Salmonella while the former did not.

With respect to mutagenicity testing of technical and analytical grades of oxyfluorfen and PCE, EPA (1981b) concluded that further study is required to define the mutagenicity of oxyfluorfen and PCE. Thus, the evidence to date indicates that oxyfluorfen is a possible human mutagen.

Sethoxydim

A recombination assay, a host-mediated assay, and two reverse mutation bacterial assays all tested negatively (EPA 1984m). Thus, the available evidence does not indicate that sethoxydim is mutagenic.

Simazine

None of the available mutagenicity studies have been validated by EPA (EPA 1985l). Simazine was negative for mutagenicity when tested in 12 microbial assay systems and in 6 in vitro DNA assays (USDA 1984a). A weakly mutagenic response and an increase in dominant lethals resulted from two studies with the fruit fly (USDA 1984a). This indicates that simazine may be mutagenic in some test systems, but there does not appear to be sufficient evidence to suggest that it is a mutagenic hazard to humans.

Fungicides

Benomyl

Benomyl tested positive in 8 of 22 mutagenicity assays for a variety of bacteria, yeast, and mammalian tests (EPA 1986a). Positive results were reported in two micronucleus tests in vivo--one in mice and one in rats. The rat micronucleus assay observed increased chromosomal damage in embryonic cells, but showed no increase in bone marrow chromosomal aberrations. The mouse micronucleus test indicated a significant dose-related increase in bone marrow micronuclei at 250, 500, and 1,000 mg/kg. Benomyl was weakly mutagenic in an in vitro mouse lymphoma test, both activated and nonactivated, and in a sister-chromatid exchange assay in Chinese hamster ovary cells in vitro. A fruit fly mutagenicity test noted sterility in some broods. Positive mutagenic results were also observed in a prokaryotic and a eukaryotic study. Based on these findings, it appears that benomyl may be mutagenic.

EPA concluded that benomyl and methyl benzimidazole carbamate (MBC, a primary metabolite of benomyl) have been shown to cause nondisjunction and aneuploidy of the cellular spindle apparatus in a variety of organisms. However, they stated that the impact of this mutagenic response on human health cannot be adequately assessed at this time. Mutagenic risk in the form of heritable spindle effects or point mutagenicity does not warrant a recommendation for regulatory action (EPA 1982, as cited in EPA 1985f).

Captan

Positive mutagenicity was observed in one test for chromosome aberrations in Chinese hamster ovary cells in vitro (EPA 1985a). However, captan was negative in an in vivo mouse spot mutation test, in three in vivo and in vitro mammalian chromosome aberration assays, and in two tests for DNA damage. An EPA (1985g) position document on captan concluded that captan is either nonmutagenic in vivo or possesses such a low mutagenic activity that it is not possible to detect. The risk for humans appears to be extremely low (EPA 1985g).

Chlorothalonil

A wide range of chlorothalonil mutagenicity tests reviewed but not classified by EPA revealed only two positive results for bacterial DNA repair (EPA 1984p). Twenty-three tests reported negative results for bacterial and mammalian point mutation, mammalian chromosome aberration, and bacterial and mammalian primary DNA damage. Five additional negative tests that were not evaluated by EPA were reported for point mutation, chromosome aberration, and DNA damage, while three additional tests were positive for bacterial point mutation and fungal DNA damage (USDA 1986b). The 4-hydroxy metabolite of chlorothalonil produced no mutagenic response in numerous tests. EPA concluded that neither chlorothalonil nor its metabolite was a mutagen in mammalian organisms (1984p).

DCNA

A recombination assay using Bacillus subtilis and a reversion assay using Escherichia coli and Salmonella typhimurium resulted in negative mutagenic results (Shirasu et al. 1976). These tests were reviewed but not classified by EPA (1984e). Tests for gene mutation in mammalian cells, chromosome aberrations, and DNA damage and repair in mammalian cells are presently lacking (EPA 1983). Available evidence thus does not indicate that DCNA is mutagenic.

Maneb

No mutagenicity studies were listed for maneb in EPA's tox one-liner; therefore, studies reported by USDA (1986b) were reviewed for this summary. Of 27 mutagenicity tests, 8 were positive for bacterial gene mutation, chromosome aberration in hamster lung fibroblast cells, and mitotic recombination in yeast. Negative results were reported in 13 bacterial assays, 2 insect assays, an in vivo rat bone marrow assay, and 3 mammalian and yeast assays for DNA damage. USDA (1986b) concluded that maneb was weakly mutagenic.

Metalaxyl

Metalaxyl was nonmutagenic when tested in a bacterial assay and a dominant lethal in vivo assay with mice (EPA 1985m). Thus, available evidence does not indicate that metalaxyl is mutagenic.

Thiram

No mutagenicity tests were summarized or graded by EPA in the thiram tox one-liners (1984o). Another report by the agency (EPA 1984s) specified a request for additional data under FIFRA for chronic, oncogenic, teratogenic, reproduction, and mutagenicity studies using thiram. Two reports, one on chromosomal aberration in cultured Chinese hamster ovary cells and one on unscheduled DNA synthesis in primary rat hepatocytes, were received by EPA in 1986 and are now being evaluated. Open literature references not graded by EPA detailed 15 positive mutagenicity assays on bacteria point mutation and DNA damage, yeast DNA damage, and rodent chromosome aberrations and DNA damage, both in vivo and in vitro (USDA

1987). Only four assays--an anaphase-telophase analysis of Chinese hamster ovary cells, a micronuclei test in mice, and two bacterial point mutation assays--were negative. Thus, the available evidence indicates that thiram is a possible mutagen to lower mammalian systems and should be considered as a potential mutagen to humans.

Triadimefon

Triadimefon was not mutagenic in a variety of test systems (EPA 1982a). A dominant lethal assay and a micronucleus test with mice produced negative results. Bacteria treated with triadimefon in an Ames assay, a recombination assay, and a reverse mutation assay both with and without activation tested negative for mutagenicity. These study results show that triadimefon is not a mutagenic substance.

Insecticides

Carbaryl

There have been numerous evaluations of the mutagenicity of carbaryl in various test systems but most were judged unacceptable by EPA (1984b). The seven studies that were accepted by EPA reported positive results for point mutation, chromosomal aberrations, c-mitotic effects, and abnormal mitosis, while one dominant lethal assay was negative for chromosomal aberrations. (Because the specific test type or test species were not given for the six positive tests in the tox one-liner, only the dominant lethal assay was included in table 2-4.) However, the dominant lethal assay is ranked relatively high among mutagenicity tests for its value in estimating the mutagenic potential of a substance to humans. The carbaryl decision document (EPA 1980) concluded that their current information did not lead to the conclusion that carbaryl is a mutagenic hazard to humans. The Reproductive Effects Assessment Group evaluated all the mutagenicity studies and concluded that "carbaryl is not a potent mutagen in the reported studies and probably acts as a weak mutagen only" (EPA 1984b).

Chlorpyrifos

Mutagenicity tests of chlorpyrifos accepted by EPA gave both positive and negative results (EPA 1985n). A positive mutagenic response was determined in a DNA repair assay with two species of bacteria and a mitotic recombination assay was weakly positive with or without metabolic activation. No mutagenic response was found in a mouse micronucleus test nor in assays with activated and unactivated Chinese hamster ovaries. In addition, results from assays reviewed by EPA that were deemed inconclusive or unacceptable indicated one positive and eight negative assays (EPA 1985n). EPA does not consider chlorpyrifos to be mutagenic. However, the available data used to assess the mutagenic potential of chlorpyrifos are not up to EPA standards and additional studies are required (EPA 1984t).

Diazinon

One bacterial assay using diazinon tested negative for mutagenicity. (Shirasu et al. 1977). Chronic studies with diazinon have revealed no

oncogenic effects. (See the discussion of diazinon in the carcinogenicity section.) Because of the results of the chronic studies, the mutagenic hazard of diazinon should be considered low.

Dimethoate

Dimethoate was positive for mutagenicity in six studies and negative in six others, according to findings evaluated and accepted by EPA (1984u). Results of bacterial tests were positive in four cases and negative in six others (EPA 1984u). Positive results were reported in a micronucleus test in vivo in mice given 51.7 mg/kg in two doses, and in a mitotic gene conversion assay in yeast at 7 concentrations (400 mM to 100 mM) (EPA 1984u). Two dominant lethal mouse assays and a cytogenicity assay in mice reported negative results, but they were deemed unacceptable studies by EPA (1984u). The positive responses in some of these tests indicate a potential for mutagenic hazard in mammalian systems. However, EPA (1979) concluded that dimethoate is of relatively low mutagenic potency based on the assays reviewed, and that its mutagenic risk to humans is very low.

Fenvalerate

Based on four laboratory studies evaluated by EPA, fenvalerate is not mutagenic. Two bacterial mutagenicity assays were negative at the highest levels of fenvalerate tested (EPA 1984v). A cytogenetic test in Chinese hamsters in vivo as well as a dominant lethal mouse assay also showed negative results for mutagenicity (EPA 1984v; USDA 1985d). A pesticide background statement on fenvalerate (USDA 1985d) indicated one positive mutagenic assay. This test on the mitotic index and chromosome division in mammalian cells in vivo was not summarized by EPA (1984v) and no data were presented to support the authors' statement that the effect was cumulative.

Fumigants

Dazomet

According to EPA (1985o), dazomet test results were negative for gene mutation in a sex-linked recessive lethal Drosophila assay and for chromosome aberration in a rat bone marrow cell assay. Tests on dazomet were positive for chromosomal aberration and primary DNA damage in a mouse lymphoma test and a sister chromatid exchange assay, both in the absence of metabolic activation. Other studies reported dazomet as nonmutagenic in bacteria with and without metabolic activation (Shirasu et al. 1981; Moriya et al. 1983). No mutagenicity tests were reported for monomethylamine and hydrogen sulfide. Mutagenicity of other dazomet degradation products are discussed below.

Methyl isothiocyanate (MITC). According to Schering AG (1983), MITC was negative for gene mutation and primary DNA damage in a variety of bacterial strains, both with and without metabolic activation.

Formaldehyde. Formaldehyde has been reported to cause genetic mutation in fruit fly larvae, fungi, viruses, yeast, and mammalian and human cells (EPA 1986f). In vitro tests have detected single strand breaks in DNA, sister-chromatid exchange in mouse bone marrow, DNA-protein crosslinks, chromosome aberrations, and marginal results in a dominant lethal assay. After a review of the data, the Consensus Workshop on Formaldehyde determined formaldehyde to be a weak mutagen (EPA 1986f). However, for regulatory purposes, further testing is required by EPA for gene mutation, structural chromosomal aberration, and other genotoxic effects.

Carbon Disulfide. Carbon disulfide was not mutagenic to two strains of *Salmonella* or to *E. coli* with and without metabolic activation. Negative results were also obtained in a fruit fly mutagenicity test (Donner et al. 1981, as cited in HSDB 1986e). Carbon disulfide did increase the frequency of sister chromatid exchange in cultured human lymphocytes exposed to 10,200 µg/l in the medium; however, at lower concentrations no effects were observed (Bassendowska-Karska 1981, as cited in HSDB 1986e; RTECS 1987c).

1,3-Dichloropropene

Tests for mutagenicity of 1,3-dichloropropene produced positive mutagenic responses with bacteria in a recombination assay, a reverse mutation assay, and a host-mediated assay (EPA 1985b). The majority of bacterial mutagenicity studies with 1,3-dichloropropene that were reported in the open literature and were not included in the EPA toxicity summary (EPA 1985h) determined positive results (USDA 1987). The lone negative result was determined from a purified sample of the chemical. The investigators that used the purified form (Talcott and King 1984) were the only ones to determine that their sample of 1,3-dichloropropene contained other chemicals that are known mutagens.

Positive results were recorded on tests for detecting primary DNA damage in mammalian cells and negative results were recorded on dominant lethal assays and spermhead evaluations for rodents (EPA 1985h). EPA (1985h) concluded that 1,3-dichloropropene directly induces gene mutation and DNA damage in prokaryotic cells. The fact that positive mutagenic results were determined even in several studies that used 1,3-dichloropropene samples of greater than 98 percent purity, while Telone II contains 1,3-dichloropropene known to have manufacturing impurities, implies that Telone II may be mutagenic to humans.

Methyl Bromide + Chloropicrin

Bacterial assays indicate that methyl bromide can be weakly to strongly mutagenic (USDA 1986b). Five tests revealed positive results, including four point mutation assays with bacteria and mouse lymphoma cells and one sex-linked recessive lethal assay in fruit flies. Two tests revealed negative results for mammalian DNA damage. Methyl bromide thus can be considered a weak mutagen.

Few mutagenic assays on chloropicrin have been reported. It was found to be weakly mutagenic in a bacterial assay and nonmutagenic in a sex-linked recessive lethal test and a heritable chromosome test using Drosophila (USDA 1986b). The mutagenicity of chloropicrin is questionable but the mixture of methyl bromide with chloropicrin can be categorized as weakly mutagenic.

Vorlex

The mutagenicity and toxicity of Vorlex is influenced by its major components, methyl isothiocyanate (MITC) and 1,3-dichloropropene, and an inert ingredient, xylene. No chronic feeding or mutagenicity studies with MITC or Vorlex are reported in the open literature or by EPA (1984k). Bacterial assays that measured reverse mutation and DNA damage/repair and an Ames test with MITC were negative for mutagenicity in studies conducted and summarized by Schering AG (1983).

Two Ames tests using a formulation of Vorlex without xylene indicated a general toxic effect upon the bacteria used both with and without metabolic activation but no mutagenic activity (Schering AG 1983). These results disagree with the mutagenicity tests on 1,3-dichloropropene previously discussed. 1,3-Dichloropropene was found to be mutagenic to the same bacterial strain. Schering AG (1983) concludes that "the mutagenic potential of Vorlex cannot be shown in this test system because the bactericidal effect of the non-mutagenic MITC portion is already evident before the onset of the 1,3-dichloropropene mutagenic effect."

CARCINOGENICITY OF THE 28 PESTICIDES

The following discussion summarizes the results of cancer tests and other chronic tests that have been used to determine whether any of the 28 pesticides is carcinogenic. Table 2-5 presents a summary listing of those results.

Herbicides

Atrazine

Available data suggest that atrazine may be carcinogenic. In an 18-month mouse feeding study, atrazine did not induce any tumors at 12.5 mg/kg/day (Innes et al. 1969). A 2-year oncogenic feeding study of rats resulted in a significant increase in mammary tumors upon exposure to the dosage levels of 70, 500, and 1,000 ppm (3.5, 25, and 50 mg/kg/day). Based on the occurrence of mammary tumors in female rats, atrazine appears to be carcinogenic in rats (USDA 1986a). Atrazine's cancer potency is discussed in the next section.

Bifenox

No chronic studies for bifenox have been accepted by EPA (1981a). Examination of procedures used at Industrial Bio-Test Laboratories revealed many discrepancies that led to the invalidation of chronic studies on bifenox conducted at this facility. A 2-year chronic feeding study with

dogs has not been validated and is not available for review (Rhone-Poulenc 1984). No effects were shown at doses up to 600 ppm (15 mg/kg/day) (Rhone-Poulenc 1986). Rhone-Poulenc Inc. (1986) also reports that a new 1-year dog feeding study showed no observable toxic effects at doses up to 1,000 ppm (25 mg/kg/day) and a 2-year mouse feeding study showed no oncogenic effects at doses up to 1,000 ppm (50 mg/kg/day) in the diet. EPA (1981a) has requested additional chronic feeding studies using bifenox.

2,4-D

A number of studies have assessed the carcinogenicity of 2,4-D, and thus far, there are no conclusive data demonstrating the carcinogenicity of 2,4-D (IARC 1977, Mullison 1981, and State of Minnesota 1978, all as cited in USDA 1984a). However, there is also general agreement that none of these studies were adequate (EPA 1982b; IARC 1977, as cited in USDA 1984a; WHO 1984). At least one scientist, Dr. M. Rueber, disputes the conclusion that a carcinogenic effect of 2,4-D has not been shown (Rueber 1979, as cited in BLM 1985).

EPA has recently reviewed a long-term study on the oncogenic potential of 2,4-D. Preliminary findings indicate an increased incidence of brain tumors in rats. But EPA's review of the recent cancer study is not yet complete. EPA has requested an independent expert to review the brain tissue slides from this study and may also request a review of this study by the Scientific Advisory Panel. Thus, a thorough review of this study may take months to complete. Therefore, EPA does not believe it is now appropriate to derive a specific numerical estimate of cancer potency based on the new data, but has stated that from its preliminary review, the level of cancer potency indicated by the reported results would be of about the same order of magnitude as the potency value based on the Hansen study (Hansen et al. 1971) that has been used in previous risk analyses (EPA 1986c).

At 106 weeks, a preliminary pathology report from a recent mouse study found that 2,4-D was not oncogenic at dosages of 1, 15, and 45 mg/kg/day (Hazelton 1986).

Hoar et al. (1986) recently completed a case-control epidemiologic study in Kansas that examined the risk of lymphoma and soft-tissue sarcoma in men from agricultural herbicide exposure. The study found no association between exposure and soft-tissue sarcoma or Hodgkin's disease, but it observed a significant association between non-Hodgkin's lymphoma and phenoxyacetic acid herbicide exposure, especially 2,4-dichlorophenoxyacetic acid exposure. Individuals exposed to herbicides for more than 20 days per year had a sixfold increase in non-Hodgkin's lymphoma.

This study, however, suffers from the same inherent limitations as other case-control studies, mainly that it relies on the subject's and the next of kin's recall of exposure status. If recall is faulty, then misclassification occurs. Assessing exposure-disease relationships in this type of epidemiological study is especially difficult (Thomas 1986). For example, common exposures to other carcinogenic agents or other factors may result in disease but be undiscovered in the interview and confound the

results. Thus, uncontrolled confounding factors in observational epidemiological studies can be particularly troublesome in interpreting the results. The apparent dose-response relationship observed in the Hoar et al. (1986) study for non-Hodgkin's lymphoma (NHL) is of public health concern and needs further examination.

A recent review of the study, conducted for EPA by Brian MacMahon, M.D., Ph.D., of the Harvard School of Public Health concluded:

> In my opinion the weight of evidence does not support the conclusion that there is an association between exposure to 2,4-D and NHL. It is axiomatic that, except when relative risks are very high--and sometimes even then--no single study will establish an association between an exposure and an outcome. The acceptance of an association depends on a number of studies showing consistent results across populations and across different epidemiologic methods. The study of Hoar et al. is a strong study--strong enough on its own to establish a hypothesis of relationship of exposure to 2,4-D with some small proportion of cases of NHL--a hypothesis that clearly deserves attempts at refutation or support in other populations. When one attempts to place the results of this study among the results of those published previously, the picture becomes very confusing, much more so than if Hoar et al. had been the only study published. Taken as a whole, I believe that the weight of evidence indicates that an association between 2,4-D and NHL remains a hypothesis that is still to be tested. I am unwilling to speculate as to whether 2,4-D causes NHL (or some cases of NHL) until the evidence is clear that there is an association between them (MacMahon 1986).

Now under way are at least two more studies that should be helpful in assessing risk to humans from the use of 2,4-D and other phenoxy herbicides (Colton 1986). In view of the uncertainty regarding the carcinogenicity of 2,4-D, a cancer risk analysis was conducted in this risk assessment under the assumption that 2,4-D is carcinogenic.

DCPA

There is no evidence that DCPA is carcinogenic. Chronic feeding studies (2-year) using dogs and rats showed no effects at the highest doses tested (greater than 10,000 ppm for both animals; approximately 750 mg/kg/day) (EPA 1984f).

Hexachlorobenzene (HCB) is a contaminant of DCPA formulations and may have constituted up to 5 percent of the formulations used for the above chronic studies (USDA 1987). HCB administered to hamsters for the life of the animals produced significant increases in total tumors, thyroid tumors, and liver tumors (Cabral et al. 1977). Carcinogenesis would have been expected to occur in the DCPA chronic feeding studies if HCB were sufficiently toxic. The current maximum concentration of HCB in DCPA formulations is 0.3 percent.

Dicamba

Available evidence does not indicate that dicamba is carcinogenic. A 2-year rat feeding study resulted in the absence of any toxic or oncogenic effects of dicamba at 500 ppm (25 mg/kg/day) (HDT) (EPA 1984h). No oncogenic effects were reported in a 2-year dog feeding study (EPA 1984h). EPA has requested additional cancer studies for dicamba because the available studies are not considered adequate for defining the oncogenic potential of dicamba based on EPA guidelines under FIFRA (EPA 1985e).

A recent 2-year rat study accepted by EPA (1986g) showed no oncogenic or systemic effects at the highest dose tested (2,500 ppm).

Diphenamid

Two-year feeding studies with diphenamid in rats and dogs revealed no oncogenic effects at doses up to 30 mg/kg/day (highest dose tested in both species) (EPA 1984i). However, dog studies are considered appropriate only for determining chronic toxicity other than oncogenicity. The oncogenic potential of diphenamid cannot be determined, however, without a valid mouse feeding study of at least 18 months' duration.

Glyphosate

A 26-month rat feeding study found no oncogenic effects at doses up to 31 mg/kg/day (EPA 1984j). However, this study was downgraded to supplementary because the maximum tolerated dose (MTD) was not reached. Benign kidney tumors (renal tubular adenomas) were found at the highest dose level (30,000 ppm) in a 2-year mouse feeding study; however, the findings were equivocal. The EPA Science Advisory Panel has reviewed all relevant data and concluded that the oncogenic potential of glyphosate could not be determined from existing data and proposed that the study be repeated to clarify these equivocal findings (EPA 1986c). EPA is requiring that the mouse study be repeated with more animals in each test group to increase the statistical value of the study. In view of the uncertainty regarding the carcinogenicity of glyphosate, a cancer risk analysis was conducted in this risk assessment.

A carcinogenic nitrogen derivative of glyphosate, N-nitrosoglyphosate (NNG), is not considered a potential human hazard here because NNG is not likely to form in soils at the application rates used in forestry. Details concerning NNG are presented in the Supplement to the Environmental Impact Statements on Management of Competing Vegetation (BLM 1986).

Napropamide

Available information indicates that napropamide is not carcinogenic. Chronic feeding studies using rats and mice revealed no oncogenic effects (EPA 19841).

Oxyfluorfen

Chronic studies in which oxyfluorfen was fed to rats and mice over 2 years and 20 months, respectively, produced no statistically significant increase in the incidence of tumors. EPA evaluated both studies (1981b) and determined that the rat study lacked a maximum threshold level, and that in the mouse study the increase in the incidence of liver tumors with increasing doses was not a statistically significant increase over controls even in the highest dose. No oncogenic effects were reported in a 2-year dog feeding study (EPA 1985c).

Oncogenic and chronic studies of perchloroethylene (PCE), a contaminant of oxyfluorfen, have shown mixed results. Two of the negative tests, a mouse skin bioassay and a 12-month rat feeding study, were criticized by EPA for lack of statistical validity and a maximum threshold, respectively. A rat embryo cell test and a 90-week mouse study gave statistically significant positive results. Mice exposed to very high doses of PCE given intermittently for 50 weeks (3,900 mg/kg/week) and 62 weeks (3,900 mg/kg/week) showed carcinogenic effects (RTECS 1986, as cited in NLM 1986d).

This risk analysis assumes that oxyfluorfen, as used, is carcinogenic because of the PCE impurity present.

Sethoxydim

No oncogenicity was observed in two chronic feeding studies with mice and rats (EPA 1984o). It is concluded that sethoxydim is not carcinogenic.

Simazine

The limited chronic studies conducted on simazine do not indicate that simazine is carcinogenic (EPA 1984n). EPA has requested additional data to assess the possible carcinogenicity of simazine.

The positive evidence of cancer in the study on the atrazine-simazine mixture (Fogard-S) described in the discussion of atrazine is consistent with the positive evidence of the carcinogenicity of atrazine. However, this mixture is not generally used in Forest Service nurseries.

Fungicides

Benomyl

Positive oncogenicity studies include two benomyl and two MBC mouse studies. MBC is a primary metabolite of benomyl and is considered by many investigators to be the biologically active agent of benomyl. This hypothesis has supporting data but has yet to be proven (USDA 1986b). Chronic feeding studies with dogs and rats detected no oncogenicity from benomyl ingestion (EPA 1985f). EPA is currently evaluating the weight of various studies to assess the oncogenic potential for benomyl. This pesticide will be considered as a carcinogen in the risk assessment.

Captan

Studies have found statistically significant dose-related increases in adenocarcinomas in the gastrointestinal tracts of mice and in kidney tumors for male rats. Captan is a demonstrated animal carcinogen and is considered as a probable human carcinogen (EPA 1985g).

Chlorothalonil

A chronic rat feeding study found induced renal carcinomas and adenomas but was determined to be deficient in design and execution and given a supplemental rating (EPA 1984p). No evidence of carcinogenicity was found in an 80-week mouse feeding study. An additional mouse feeding study with chlorothalonil detected renal tubular adenomas and carcinomas in males but not females. There was no dose-dependent relationship for induction of neoplasms and therefore the evidence for the tumorigenicity of chlorothalonil in the kidney remains inconclusive (EPA 1984p).

Two chronic studies on rats and mice evaluating the oncogenic potential of the 4-hydroxy metabolite of chlorothalonil revealed no positive carcinogenic results. Evidence of RBC hemolysis, increased reticulocyte count, morphological changes in leukocytes and erythrocytes, and hemosiderin in the spleen were demonstrated at dose levels of 53.5 to 214 mg/kg in the mouse study (EPA 1984p). EPA requested an additional rodent study to further evaluate the oncogenic potential of chlorothalonil.

Hexachlorobenzene (HCB) is a contaminant in chlorothalonil at concentrations generally less than 0.05 percent and is also a suspected animal carcinogen (EPA 1984p). It is assumed in this risk analysis that chlorothalonil is carcinogenic to humans.

DCNA

A 2-year rat feeding study provided no evidence of tumorigenicity for DCNA (EPA 1984e). An 18-month oral dosing study in mice revealed no oncogenic effects from DCNA administration (Innes et al. 1969). EPA has reported that an oncogenicity study with mice is in progress. According to these data, DCNA is not oncogenic (EPA 1983).

Maneb

Two chronic studies with rats revealed a slight increase in tumors for treated rats versus control rats but were inconclusive because of the small number of surviving animals in the treated groups (USDA 1986b). Two strains of mice tested for 78 weeks revealed no statistically significant increase in tumors (Innes et al. 1969); but an additional study in two strains of mice resulted in a significant increase in lung adenomas in one of the two strains within 9 months (IARC 1976, as cited in USDA 1986b).

Three carcinogenicity studies that involved oral dosage and feeding of ETU (a metabolism product of maneb) to rodents resulted in significant increases in thyroid carcinomas for the two rat studies and hepatomas and lymphomas in the mouse study (USDA 1986b).

Because of the significant increase in lung adenomas in one strain of mice treated with maneb and the known carcinogenicity of ETU, maneb must be considered as a potential human oncogen.

Metalaxyl

There is no evidence from two laboratory studies evaluated and accepted by EPA that metalaxyl is carcinogenic. A 2-year rat study found that metalaxyl was not oncogenic up to 62.5 mg/kg/day, which was the highest dose tested. Additionally, no effects were observed at doses up to the maximum tested (1,250 ppm = 187.5 mg/kg/day) in a 2-year mouse study (EPA 1985m).

Thiram

EPA has requested additional oncogenicity studies to satisfy FIFRA requirements for the registration of thiram (EPA 1984s).

An 80-week rat feeding study not accepted by EPA (1984q) showed no difference in number of or latency period from the spontaneous tumors seen in control rats. A 2-year rat feeding study not specifically evaluated by EPA found no increased incidence of tumors after administration of thiram (Lijinsky 1984, as cited in USDA 1987). A coincident test under the same conditions except for the dietiary administration of 2,000 ppm sodium nitrite with 500 ppm thiram produced a high incidence of tumors in the nasal cavities of both sexes of rats. A significant increase in papillomas of the forestomach was also found. Nitrosodimethylamine, a known carcinogen, is the probable product from nitrosation of thiram (Lijinsky 1984, as cited in USDA 1987). No significant tumorigenicity for thiram was found in an 18-month multipesticide mouse feeding study (Innes et al. 1969). Although this study was not discussed or reviewed in EPA toxicological reports concerning thiram (EPA 1984q,s), it was given a supplemental rating for another pesticide (EPA 1984a).

Although no oncogenic response to thiram has been established in any studies, the preponderance of mutagenicity data suggests that thiram is a potential carcinogen. However, until additional toxicological tests, including oncogenicity studies, are completed, the carcinogenic potential of thiram cannot be estimated; therefore it is not included in the risk assessment.

Triadimefon

Chronic studies using triadimefon have revealed no carcinogenic effects (EPA 1982a). No oncogenic effects were noted at the highest doses tested in 2-year feeding studies with rats (5,000 ppm = HDT) and mice (1,800 ppm = HDT). A 2-year dog feeding study found no increase in tumorigenicity. All of these studies were accepted as minimum grade by EPA (1982a). Triadimefon is treated as nononcogenic in this analysis.

Insecticides

Carbaryl

The majority of studies examining the oncogenic potential of carbaryl to mammals have been negative (EPA 1984b). The tests utilized oral doses, feeding methods, skin injections, and intraperitoneal injections. No studies with mice have found evidence of tumorigenicity. A 2-year rat feeding study was negative for carcinogenic effects at 400 ppm (20 mg/kg/day)(HDT) (EPA 1984b).

A 22-month rat feeding study at a 30 mg/kg dose level (HDT) resulted in increased tumorigenicity of the surviving test animals. Rats that were administered a subcutaneous dose of 20 mg of carbaryl showed an increase in tumors relative to control animals; however, the purity of the test material is questionable. The increases in tumorigenicity for treated rats versus control animals in these studies were not statistically significant (EPA 1984b).

N-nitrosocarbaryl is a compound that can cause mutations and cancer and may be formed from carbaryl under acidic conditions like those found in the human stomach. However, this compound may be rapidly metabolized in mammals so that it exists only a short time in the stomach and thus poses no cancer risk (USDA 1985a). This analysis uses the most conservative assumption, that N-nitrosocarbaryl is not rapidly metabolized, to evaluate the risk of cancer to humans from carbaryl ingestion.

Chlorpyrifos

Chlorpyrifos has not exhibited any oncogenic potential in two studies submitted to EPA (EPA 1985n). However, the 2-year chronic rat study was limited by inadequate reporting of histology, clinical observations, and body weights, and the mouse oncogenicity study of 2 years' duration may not have been conducted using the maximum tolerated dose (EPA 1984t). EPA has determined that these studies must be upgraded or repeated to be adequate for regulatory purposes (EPA 1984t). EPA does not consider chlorpyrifos to be oncogenic.

Diazinon

No evidence of oncogenicity for diazinon was determined in three oncogenic feeding studies with rats; in a 2-year feeding study with rats at levels in the diet up to 800 ppm (EPA 1984g), in a 2-year feeding study with rats at diet levels up to 1,000 ppm (EPA 1984g), and in a 106-week feeding study with monkeys.

Dimethoate

EPA (1984u) has reviewed four studies for carcinogenicity of dimethoate; two of these were positive. An additional positive study was reviewed and discussed by USDA (1985c). Dimethoate was carcinogenic in rats when administered orally at 5, 15, or 30 mg/kg or intramuscularly at 15 mg/kg (EPA 1984u; USDA 1985c). Granulocytic leukemia was induced in

mice by dermal application of 3 or 5 percent dimethoate twice weekly for 6 months (EPA 1984u; USDA 1985c), and in rats by gastric intubation of 5, 10 or 15 mg/kg (in a study not reviewed by EPA) (USDA 1985c). Two feeding studies observed no effects at the highest dose tested of 500 ppm in rats and mice (EPA 1984b).

Fenvalerate

One positive and three negative carcinogenicity studies for fenvalerate were reviewed by EPA. A 24-month rat oncogenicity study resulted in the production of a statistically significant level of spindle cell sarcomas at the dose level of 1,000 ppm (50 mg/kg/day) in male rats; in addition, EPA determined that there was a positive correlation between the inducement of spindle cell sarcomas and other toxic effects observed at 1,000 ppm (EPA 1984v). A 24-month and an 18-month oncogenic study of mice reported no statistically significant carcinogenic effects at the highest doses tested of 1,250 ppm (37.5 mg/kg/day) and 3,000 ppm (45.0 mg/kg/day), respectively (EPA 1984v). A 24-month rat feeding study reported no oncogenic effects at the highest dose tested of 250 ppm (12.5 mg/kg/day) (EPA 1984v).

All four mutagenic tests evaluated bye EPA (for point/gene mutations, chromosome aberrations, and primary DNA damage) were negative (EPA 1984v; USDA 1985d). Of the four reported carcinogenicity studies, only one found statistically significant evidence of malignant tumors. In that study, one dose was given and no compound-related oncogenic effects were noted in female rats. On the basis of combined information from mutagenicity and carcinogenicity studies, it is highly probable that exposure to fenvalerate does not present a mutagenic or carcinogenic risk to humans.

Fumigants

Dazomet

No oncogenic effects were reported in a 2-year rat feeding study at doses of 0.5 to 2 mg/kg/day (Gosslin et al. 1984, as cited in HSDB 1986a). No other oncogenicity studies have been reported. No oncogenicity studies have been reported for hydrogen sulfide, carbon disulfide, and monomethylamine. Cancer studies of other dazomet degradation products are discussed below.

Methyl isothiocyanate (MITC). According to Schering AG (1983), no oncogenic effects were seen in a chronic toxicity study in mice given up to 200 ppm (30 mg/kg/day) or in rats given up to 50 ppm (2.5 mg/kg/day).

Formaldehyde. EPA (1986f) has classified formaldehyde as a probable human carcinogen and has placed it in Group B, indicating sufficient evidence of carcinogenicity in animals and limited evidence of carcinogenicity in humans. In long-term inhalation studies conducted by the Chemical Industry Institute of Toxicology (CIIT), rats developed statistically significant numbers of nasal tumors (EPA 1986f). Although nasal tumors were observed in mice, they were not statistically significant. Two other chronic inhalation studies performed on mice and

hamsters did not demonstrate any carcinogenic effects (EPA 1986f). Stomach tumors were observed in rats given drinking water that contained 0.5 percent formaldehyde (Takahashi et al. 1986, as cited in EPA 1986f).

EPA (1986f) has reviewed 28 epidemiological studies of formaldehyde exposure. Eight studies among different occupational groups indicate significant associations between site-specific respiratory cancer and exposure to formaldehyde (EPA 1986f). In addition, a group of professionals, including anatomists, pathologists, embalmers, and undertakers, exposed to formaldehyde showed significantly increased mortality from leukemia and brain neoplasms. A recent study conducted by the National Cancer Institute reported that there is little evidence that mortality from cancer is related to formaldehyde exposure at levels experienced by workers (EPA 1986f). However, a recent OSHA-NIOSH study found a statistically significant excess in mortality caused by cancers of the buccal cavity and connective tissue in garment workers exposed to formaldehyde (EPA 1986f). EPA (1986f) concluded that the epidemiology studies suggested that formaldehyde may be a human carcinogen, though the evidence was classified as limited because exposures to multiple chemicals may have confounded the findings of excess cancers.

1,3-Dichloropropene

Three chronic studies revealed that 1,3-dichloropropene was oncogenic to rodents (EPA 1985h). In a mouse study, localized tumors (fibrosarcomas) were developed at the site of weekly injections after 538 days. The compound was purified before injection, so it is unlikely that any contaminants produced the fibrosarcomas.

An increased occurrence of several benign and malignant tumor types was observed in rats and mice that received 1,3-dichloropropene by gavage. The gavage studies used a formulation of 1,3-dichloropropene that contained 1 percent epichlorohydrin, a known mutagen and carcinogen in laboratory animals. Forestomach squamous cell papillomas and carcinomas were found in both female and male rats gavaged with epichlorohydrin at 2 mg/kg/day in a 2-year study (Webster et al. 1984, as cited in EPA 1985h). However, neoplasms other than those described above were found in the 1,3-dichloropropene gavage studies. EPA (1985h) concluded that epichlorohydrin may have a contributive role to the positive oncogenic effect of the 1,3-dichloropropene formulation but that the different neoplasms found suggest that 1,3-dichloropropene is a carcinogen by itself.

A 2-year mouse feeding study reported reduced survival rate in females and an increased incidence of urinary bladder epithelial cell hyperplasia (EPA 1986e). Therefore, the chemical is assumed to be oncogenic to mammals.

Methyl Bromide + Chloropicrin

At the present time, only one study links methyl bromide exposure to oncogenic effects (Danse et al. 1984). Rats were treated by gavage 5 days a week for 13 weeks. Squamous cell carcinomas of the forestomach were found in the high dose group (50 mg/kg) with hyperplasia of the stomach resulting in the 2 and 10 mg/kg dose groups. The authors suggest that

further studies are required before extrapolation to establish human risk by a mathematical model is attempted.

Reduced survival rates in two rodent studies precluded an adequate evaluation of the oncogenic potential of chloropicrin, though no increased incidence of tumors was observed in either study (USDA 1986b). The risk analysis will estimate the possibility of carcinogenic response to the mixture of methyl bromide and chloropicrin based on the oncogenic potential of methyl bromide indicated in the above study.

Vorlex

MITC is presumed to be nononcogenic to mammalian systems. (See the previous discussion on MITC in the Dazomet section.) However, the oncogenic potential of 1,3-dichloropropene, discussed in a previous section, must be considered in evaluating the oncogenic potential of Vorlex.

CANCER POTENCY

This subsection presents the results of the cancer potency analysis for each of the pesticides assumed to be carcinogenic in this risk assessment. The cancer potency value is used later in the risk analysis to determine the human cancer risk under specified assumptions about lifetime human exposure.

The cancer potency (Q*) of a chemical is defined as the increase in likelihood of getting cancer from a unit increase (1 mg/kg/day) in the dose of the chemical. One possible form of the risk-dose relationship is illustrated in figure 2-2. The curve, derived from tumor data generated in laboratory animal studies, specifies the cancer probability for each dose. Note that the dose levels used in the laboratory cancer studies are high, although exposures to humans are expected to be low. Note also that the line relating dose to cancer probability approximates a straight line in the low dose region. The slope of the curve in this region is the cancer potency.

Several aspects of this analysis tend to make the cancer potency estimates very high and subsequent judgments of cancer risk very conservative (pessimistic). First, it is assumed that any dose, no matter how small, has some probability of causing cancer.

Second, in extrapolating from the high doses used in animal studies to the far lower doses humans may get, a conservative model was used. This is one of the principal areas of scientific controversy in cancer risk assessment. Several models, including the Weibull and multistage models, have been used for the extrapolation of cancer data to assess human risk. However, among the most widely used models, the one-hit model used in this analysis gives the highest estimate of cancer potency, and, in turn, the highest estimates of cancer risk at the low doses liable to be seen in exposed humans. Cancer potency estimates calculated by EPA using the linearized multistage model were used in a few cases where they were available, but all of the potency estimates calculated specifically for

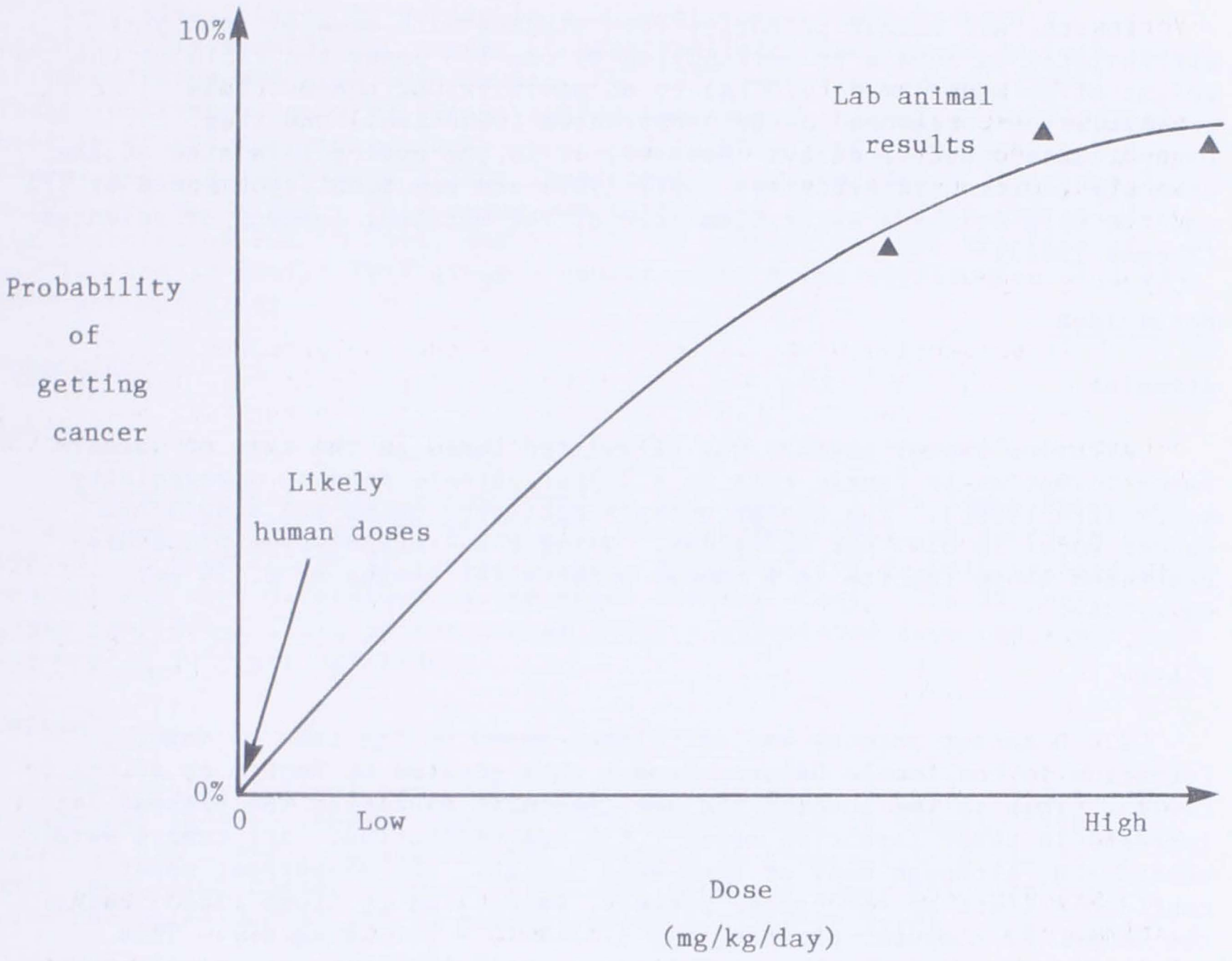

Figure 2-2--Cancer potency curve

this analysis were obtained using a least-squares regression procedure and the one-hit model.

Third, the cancer potency used in the calculation of human risk in this analysis is not the maximum likelihood estimate of the cancer potency, but the upper limit value of the 95-percent statistical confidence interval. Using this upper limit value gives a potency that is approximately 2 to 8 times as high as the maximum likelihood potency estimate.

Fourth, all cancer potencies from studies with mice or rats were extrapolated to humans by multiplying by the 1/3 power the ratio of the weight of an adult human (70 kg) to an adult rat or mouse. This extrapolation procedure may be unwarranted (OSTP 1985) and thus overestimate cancer potency. However, it is the most pessimistic of the commonly accepted alternatives (OSTP 1985) and has been recommended by EPA and the Safe Drinking Water Committee of the National Academy of Sciences (Thomas 1986).

Herbicides

Atrazine

Atrazine cancer potency was calculated based on the rate of mammary tumor formation in female rats in a 2-year chronic feeding oncogenicity study (EPA 1986c). The cancer potency estimated using the single hit cancer model is 0.03 per mg/kg/day. Using the extrapolation procedure described above results in a cancer potency for humans of 0.174 per mg/kg/day.

2,4-D

2,4-D cancer potency was calculated based on the rate of tumor formation in the female Osborne-Mendel rats studied by Hansen et al. (1971). This is the species and sex that have exhibited the highest increase in tumor formation after 2,4-D administration. All tumors were considered, although many of them were benign. The 95-percent upper confidence limit of the cancer potency, calculated by Crump (1983) using the GLOBAL 82 computer program, was 5.03×10^{-3} per mg/kg/day. This value was corrected for the surface area ratio between test animals and humans to obtain the cancer potency of 2.92×10^{-2} per mg/kg/day used for this analysis.

Glyphosate

Glyphosate's cancer potency was based on the rate of kidney tumor formation in male mice in the feeding study reported in EPA (1985i). The upper 95-percent limit of the cancer potency of glyphosate calculated from the kidney tumor data was 2.4×10^{-5} per mg/kg/day.

Oxyfluorfen

The cancer potency of oxyfluorfen was calculated from tumor data on studies with perchloroethylene (PCE), a contaminant of oxyfluorfen. A 20-month oxyfluorfen mouse feeding study showed an increase in liver tumors significantly related to dose but not significant in comparison to control animals (IRDC 1977, as cited in EPA 1981b). EPA determined that PCE was likely not the cause of the tumorigenicity observed by calculating the dose of PCE that the mice received (Albert 1980, as cited in EPA 1981b).

PCE administered by gavage in a 90-week mouse study induced a statistically significant number of hepatocellular carcinomas in both sexes of mice at low and high dose levels (NCI 1977, as cited in EPA 1981b). These tumor data, used by EPA to assess the cancer potency of oxyfluorfen because of its PCE contaminant, were used in this risk assessment. The cancer potency calculated at the 95-percent upper confidence limit was 3.41 x 10^{-2} per mg/kg/day. This value was multiplied by 0.0002 to correct for the fraction of PCE in Goal, and by 4.25 to correct for the fraction of oxyfluorfen in Goal. This gives a cancer potency for oxyfluorfen of 2.93 x 10^{-5} per mg/kg/day.

Fungicides

Benomyl

Benomyl cancer potency was based on the rate of liver tumor formation in a 2-year chronic feeding study with mice (DuPont 1983, as cited in EPA 1985f). A significant increase in lung carcinomas for animals treated with benomyl was also determined in the mouse feeding study. The 95-percent upper confidence limit of the cancer potency calculated from the tumor data was 6.67 x 10^{-3} per mg/kg/day.

Captan

The cancer potency for captan used in this analysis was based on the 2-year rat feeding study conducted by Stauffer Chemical Company (1982, as cited in EPA 1985g). A significant increase in kidney tumors was found for male rats. The cancer potency calculated from the tumor data was 5.44 x 10^{-3} per mg/kg/day at the 95-percent upper confidence level.

Chlorothalonil

EPA's evaluation of the rat chronic/oncogenicity study has revealed that chlorothalonil produces a dose-dependent increase in renal tubular adenomas and carcinomas in male and female rats and a statistically significant increase in the incidence of gastric mucosal tumors in the high dose females. A mouse study reviewed by EPA gave a calculated Q* value of 2.4 x 10^{-2}. This has led EPA to the tentative conclusion that chlorothalonil is an oncogen (EPA 1984p).

Maneb

Maneb has produced oncogenic results in several chronic tests but the significance of tumor data is difficult to evaluate because of the small numbers of surviving animals in two rat studies and the lack of a significant increase in tumorigenicity in one of two strains of mice. Ethylenethiourea (ETU) is the dominant metabolite of maneb in animals, plants, and soils under most conditions and has caused a significant increase in tumorigenicity in various chronic studies. Data on thyroid carcinomas from a 2-year rat feeding study with ETU (Ulland et al. 1972, as cited in USDA 1986b) was used to calculate a cancer potency of 0.556 per mg/kg/day of maneb at the 95-percent upper confidence level.

Insecticides

Carbaryl

Neither a statistically significant increase in tumors nor a dose-related trend was found in six chronic studies with carbaryl. No carcinogenicity was observed when rats were fed carbaryl with nitrite, even up to doses causing acute toxic effects (Lijinsky and Taylor 1977, as cited in USDA 1985a). However, there remains some concern that nitrite ions and carbaryl might react to produce N-nitrosocarbaryl, which can cause cancer. The acidity necessary for this reaction to occur in humans can only be found within the stomach. Therefore, potential exposure to nitrosocarbaryl could only occur by dietary exposure to carbaryl. Dietary exposure to carbaryl for 2 years at 20 mg/kg/day resulted in no carcinogenic effects in rats (EPA 1984b).

Tumor results from chronic gavage studies with rats exposed to nitrosocarbaryl were used to calculate cancer potencies and to determine a potency for humans. (Lijinsky and Taylor 1976 and Lijinsky and Schmal 1978, as cited in USDA 1985a). The cancer potency was 1.35×10^{-1} per mg/kg/day at the 95-percent upper confidence level. One percent of carbaryl was assumed to be converted in the stomach to nitrosocarbaryl. The cancer potency for nitrosocarbaryl was assumed to be linear and thus was multiplied by 0.01 to estimate the cancer potency of carbaryl.

Dimethoate

The cancer potency for dimethoate used in this analysis was based on the formation of malignant neoplasms in a 2-year rat study conducted by Gibel et al. (1973) as cited in Reuber (1984) and EPA (1984u). A statistically significant increase in tumors was found in rats at the highest dose tested (30 mg/kg). The cancer potency calculated from the tumor data was 6.73×10^{-2} per mg/kg/day.

Fumigants

Dazomet

The cancer potency estimate for dazomet was based on the amount of formaldehyde formed as a soil breakdown product. Based on a Chemical

Industry Institute of Toxicology (CIIT) rat study, EPA (1986g) calculated a unit cancer risk of 1.3×10^{-5} corresponding to an exposure of 1 $\mu g/m^3$ of formaldehyde continuously over a 70-year period. The potency is based on aerial concentration rather than feeding level because the exposure is through inhalation. This potency times the expected formaldehyde concentration averaged over a 70-year lifetime gives the cancer risk.

1,3-Dichloropropene

The results from the two chronic studies on mice and on rats indicate increased tumor rates in both sexes of both species (EPA 1986e). It appears that the male rats are the most sensitive in that increasing doses of the chemical produces significantly increasing numbers of forestomach and liver tumors. The cancer potency in male rats was 3.3×10^{-2} per mg/kg/day. The potency estimate for human exposures based on these data is 1.75×10^{-1} per mg/kg/day (EPA 1986e).

Methyl Bromide

The only study available to assess the cancer potency of methyl bromide is a 90-day rat study (Danse et al. 1984). This was used to calculate the cancer potency of methyl bromide as 1.69×10^{-1} per mg/kg/day at the 95-percent upper confidence levels. Because of the short duration of this test and the interfering effects of cytotoxicity, the authors cautioned that a low dose extrapolation of the results for long-term human exposure may be inaccurate. A 2-year rat study is currently in progress but an assessment of the oncogenic potential of methyl bromide at this time requires an estimation from the available data.

Vorlex

Vorlex is a mixture of 20 percent methyl isothiocyanate (MITC), 40 percent 1,3-dichloropropene, and 40 percent xylene. MITC has produced no oncogenic response in test animals but 1,3-dichloropropene has been shown to be carcinogenic in mammals in several studies. (See the discussion of 1,3-dichloropropene cancer potency.) Therefore, the cancer potency of Vorlex in this analysis is assumed to be 40 percent of the calculated potency for 1,3-dichloropropene. This value is 1.28×10^{-1} per mg/kg/day at the 95-percent upper confidence level.

Chapter 3
Exposure Analysis

INTRODUCTION

This chapter presents the background, methods, and results of the pesticide exposure analysis. The first section contains basic background information relevant to the exposure analysis. The terminology of pesticide use and potential human exposure from that use are discussed. The second section describes the nursery operations that involve the use of pesticides, the populations at risk, and the potential routes of human exposure. The third section presents the methods used to estimate pesticide doses to workers and members of the general public, including the methods used to determine lifetime doses in order to evaluate the risk of cancer. The fourth section provides estimates of routine and accidental doses for workers and the public and lifetime doses for each pesticide.

BACKGROUND TERMINOLOGY

This section defines some of the terms used in the discussion of exposure analysis methods and explains the relationship between the doses estimated in the analysis and the doses that might actually occur in future nursery operations.

Pesticide Characteristics

Most pesticides are formulated and sold by the manufacturer as emulsifiable concentrates (EC), wettable powders (WP), oil solutions, granules, dusts, or aerosols. Pesticides in liquid form are sold as concentrates with a specified number of pounds of active ingredient, usually between 1 and 10, per gallon of concentrate and with inert ingredients forming the remaining portion. Fumigants are generally packaged as liquified gases in pressurized containers and are applied by injecting the gas into the soil, often under a plastic tarp.

Before herbicides, fungicides, and insecticides are applied, they are normally mixed with a carrier, usually water, according to the manufacturer's label instructions for the particular treatment purpose and the desired application rate in pounds of active ingredient per acre. In ground applications, the concentrate is generally mixed with 50 to 100 gallons of carrier for every acre to be treated. Pesticide concentrate stored in 5-gallon drums or wettable powder in 1- or 5-pound bags is prepared for application and loaded into application equipment by a worker called the "mixer/loader."

Pesticide Drift

Pesticide application equipment is designed to cover the target area with a minimum of windborne off-target movement, called drift. Spray equipment nozzles are designed to produce medium to large droplets, because smaller droplets tend to remain airborne and to drift with air currents

away from the target vegetation. Insecticide sprays use somewhat smaller droplets to ensure contact with target pest insects. Despite the effectiveness of the application equipment used, some small fraction of the droplets may break up into smaller droplets that the wind could blow offsite. In nursery operations, drift is seldom a significant problem because spray booms are mounted within a few feet (18 to 30 inches) of the ground and the pesticide is applied at low pressure using large nozzles. Based on field study data, drift beyond 25 feet is less than 1 percent of the applied rate.

Downwind movement of volatile compounds, particularly fumigants, may also be a problem. Methyl bromide + chloropicrin is applied as a gas mixture under tarps so that only an operational error or accident, such as a badly seated hose fitting or a tear in a tarp, would result in any exposure during application. Tarp lifters may be exposed to lesser amounts several days after fumigation.

Exposure and Dose

Two primary conditions are necessary for a human to receive a pesticide dose that may result in a toxic effect. First, the pesticide must be present in the person's immediate environment so that it is available for intake. It must be in the air the person breathes, or on the person's skin, or in the person's food or water. The amount of pesticide present in the person's immediate environment is the exposure level.

Second, the pesticide must then move into the person's body by some route. If it is in the air, it must be inhaled into the air passages and lungs. If it is on the clothing or skin, it must penetrate the skin. The amount that moves into the body by any of these routes constitutes the dose.

Thus, although two people may be subjected to the same level of exposure--for example, two workers applying herbicide with a tractor-mounted boom--one may get a much lower dose than the other by wearing protective clothing, using a respirator, or washing immediately after spraying. Exposure, then, is the amount of pesticide available to be taken in; dose is the amount that actually enters the body.

NURSERY OPERATIONS

The Forest Service operates 11 bareroot nurseries in 8 States. These nurseries contain 2,351 acres; of these, 1,143 acres are in beds for growing plants. Approximately 1,179 acres (approximately 50 percent of the total area) are treated annually with pesticides. Table 3-1 indicates the size and location of each nursery and the number of acres treated with pesticides.

Twenty-eight different pesticides are used, but no one nursery uses all of the pesticides. Each nursery manager chooses only the particular pesticides that will best control the pests affecting the plant species in the individual nursery.

Table 3-1--Location and size of Forest Service nurseries

Nursery	Location	Number of acres		
		Total	Nursery bed	Annual pesticide treatment
Albuquerque	New Mexico	222	81	165
Ashe	Mississippi	410	125	125
Bend Pine	Oregon	213	65	40
Bessey	Nebraska	75	46	46
Coeur d'Alene	Idaho	220	131	131
Humboldt	California	209	133	133
Lucky Peak	Idaho	298	61	26
Placerville	California	157	97	100
Stone	Oregon	306	220	220
Toumey	Michigan	110	66	66
Wind River	Washington	131	118	118

This section describes the growth cycle of nursery stock and the timing of the use of pesticides to control weeds, fungus, insects, and other pests of nursery tree seedlings during this cycle. This section also describes the "affected populations"; that is, the nursery workers and the general public.

Growth Cycle of Nursery Stock

Cover Crop Year

Most of the nurseries operate on a 3- or 4-year plant growth cycle. In any nursery, some portion of the total nursery bed acreage is in each year of the growth cycle. During year zero of the cycle, the nursery bed is kept in a cover crop. Cover crops include sorghum, rye, oats, winter wheat, winter rye, vetch, and sudan grass. Herbicides such as atrazine, glyphosate, 2,4-D, dicamba, and oxyfluorfen may be used to control weeds in the cover crop. The cover crop is worked into the soil in the late summer to add organic matter to the soil.

The soil is usually fumigated in the fall and the seeds for the selected nursery stock are sown in the following spring. In some cases, fumigation is done in mid to late summer of the cover crop year and the seeds sown in the fall. Occasionally, fumigation is done in the spring prior to sowing. Fir and pine seeds may be treated with fungicides before they are sown.

Seedling Growth Year

Year one of the growing cycle is the first year of seedling growth. A number of herbicides, fungicides, and insecticides are applied as needed to control the growth of weeds, diseases, and insects. The pesticides used vary with the species of plant being grown and the target species of pest. In the Ashe Nursery in Mississippi and for some species in other nurseries, the trees are of adequate size for outplanting at the end of the first year of growth.

In the other nurseries, the growing cycle enters the second year. Pesticides may be used again to control weeds, diseases, and insects. Most species are large enough for removal from the nursery beds and for outplanting at the end of the second year.

To produce some species of plants, or extra-large plants of other species, some seedlings are kept in the nursery beds an additional year for further growth. In this case, an additional year of pesticide application may be necessary.

In each nursery, a variety of pesticides are used depending on the species of plants being grown and the pests being controlled. Because of this variety of plants, soils, pests, and pesticides, the exposures and risks of nursery pesticide use are first examined in a "generic" risk assessment and the methods are later applied to assess risks in the individual nurseries.

EXPOSURE ANALYSIS METHODS FOR A GENERIC NURSERY

Levels of Exposure

The exposure analysis is divided into two major components: worker exposures and public exposures. To represent the entire range of possible exposures from Forest Service nursery operations, three levels of possible exposure were analyzed: routine-realistic, routine-extreme, and accidental.

Routine-realistic exposures are those likely to occur under the vast majority of all applications and are based on average conditions, such as average application rate, average number of acres treated, or average time to reentry. Routine-extreme exposures represent the highest doses someone could receive under normal operating conditions. Routine-extreme exposures are based on conditions that result in high doses, such as using the highest application rate on the largest acreage, or on the highest doses observed in field studies. Because those routine-extreme exposures were based on a number of unlikely situations, they are expected to occur less than 1 percent of the time. Accidental exposure levels were determined for

a number of events that range in probability from unlikely to extremely unlikely, such as equipment failure, a pesticide spill, failure to wear protective clothing, or failure to observe proper reentry times.

To make reasonable estimates of the possible pesticide doses to workers and the public, the analysis examined a representative array of likely treatment situations. A survey of Forest Service nursery practices provided information on the types and acreages of crops treated, the pesticides used, the application rates, and the scheduling of the applications. Combining information from the various nurseries, a generic schedule of chemical application practices was constructed (table 3-2).

Routine-realistic exposures to a specific pesticide were based on the average application rates, average number of acres treated, and average number of applications per year found in table 3-2. Routine-extreme exposures were estimated from maximum application rates, acres treated, and number of applications. These rates are summarized in table 3-3. Accidental doses are based on several accident scenarios, such as a spill on the skin, and represent the highest doses that could ever reasonably be expected to occur.

The characteristics specified in each exposure situation are those that affect the dose a human might receive. For example, for workers involved in a tractor spraying operation, the number of work hours and the pesticide application rate are used in determining their doses. To calculate doses to nearby residents who may eat a garden vegetable containing pesticide residue, it was necessary to estimate how much pesticide residue gets on the vegetable and to make a realistic assumption about how much of the vegetable is eaten.

The doses estimated in these situations are not necessarily those that will occur as a result of a given treatment operation, but those that could occur if all of the specified conditions were met in an actual operation. For example, worker doses are based on actual dose levels found in field exposure studies of agricultural workers in which no protective clothing or equipment was worn. If workers were to wear protective clothing and equipment, such as long-sleeved shirts, gloves, coveralls, boots, and filter masks or respirators, during actual operations, their doses could be significantly lower than those estimated here. However, despite all precautions, workers present during treatment operations will be exposed to some extent.

Additional factors must be considered when evaluating the likelihood of a member of the public receiving a pesticide dose. For example, a nearby resident would receive a dose as high as the one estimated in this analysis from eating garden vegetables with pesticide residue only if all of the following conditions were met:

- The resident's garden was close enough to the treated area to receive some level of pesticide drift.
- The weather conditions on the day of treatment were such that the pesticide happened to drift offsite in the direction of the garden.

Table 3-2--Generic schedule for pesticide applications

Crop	Year	Pesticide	Acres	Rate (pounds/acre)	Applications per year	Month of application
Cover crop	0	Dicamba	40-110	1	1	April
Cover crop	0	Oxyfluorfen	40-75	0.5	1	Nov.
Cover crop	0	Atrazine	70	2	1	June
Cover crop	0	Glyphosate	2-28	0.4-2	1	March
Cover crop	0	2,4-D	81	1.2	6	April-Sept.
Pine	1	Oxyfluorfen	13-85	0.5	1-6	April-Oct.
Pine	1	Bifenox	3-20	3	1-2	May, July
Pine	1	Napropamide	7-65	0.5-1.5	1	April
Pine	1	Sethoxydim	85	0.4	2	May-June
Pine	1	Simazine	15	2.0	1	May
Pine	1	Glyphosate	85	0.1	1	May
Pine	1	DCPA	4-13	5.25-10.5	2	May, July
Pine	1	Diphenamid	7-13	4-10.5	1-5	June, Aug.
Pine	1	Captan	85	1.5	1	April
Pine	1	Triadimefon	50	0.5	4	April-June
Pine	1	Benomyl	85	0.5	7	May, July, Sept.-Nov.
Pine	1	Chlorothalonil	11-85	1.3-1.5	2-6	June, Aug.
Pine	1	Maneb	11	2.4	5	Aug.-Oct.
Pine	1	Diazinon[a]	6-85	0.5-4.25	1-3	April, June, July
Pine	1	Metalaxyl	7	4.6	1	June
Pine	1	Fenvalerate	15	0.1	5	June-Sept.
Douglas-fir	1	Oxyfluorfen	6	0.5	1-2	March-April
Douglas-fir	1	Bifenox	4-9	3.0	1-2	May, July
Douglas-fir	1	Napropamide	7	1.5	1	April
Douglas-fir	1	DCPA	13	10.5	1	Aug.
Douglas-fir	1	Diphenamid	9	4	2	June, Aug.
Douglas-fir	1	Fenvalerate	30	0.1	5	June-Sept.
Spruce	1	DCPA	1-2	9-10.5	2	May, July
Spruce	1	Diphenamid	1-3	4-6	1-5	April
Spruce	1	Chlorothalonil	2	1.3	1	Nov.
Spruce	1	Diazinon	2	4.25	1	June
Other conifers	1	Bifenox	1-65	3	2	May, July
Other conifers	1	Oxyfluorfen	40-70	0.5	1	April
Other conifers	1	Benomyl	0.5	0.25	2	July-Aug.
Other conifers	1	Chlorothalonil	0.5-13	1-1.5	2-3	July-Aug.
Other conifers	1	Diphenamid	0.7-13	2.2-6	1	April
Other conifers	1	DCNA	0.7-13	2	1	April
Other conifers	1	DCPA	0.7-13	5.25-10.5	1	July
Other conifers	1	Napropamide	5	1.5	2	April
Other conifers	1	Fenvalerate	5	0.1	5	June-Sept.
Other conifers	1	DCNA	5	1.0	2	May-July
Hardwoods	1	DCPA	2	5.25	2	May-June
Hardwoods	1	Carbaryl	1	0.8	2	June-Aug.
Pine	2	Oxyfluorfen	13-32	0.5-2.2	1-2	March, Sept.
Pine	2	DCPA	4-13	5.25-10.5	2	April, Aug.
Pine	2	Diphenamid	5-13	4-10.5	2	April, Aug.
Pine	2	Bifenox	3-20	3	1-2	May, Aug.
Pine	2	Napropamide	4	1.5	2	June-July
Pine	2	Chlorothalonil	12	1	10	May-Aug., Nov.

Table 3-2--Generic schedule for pesticide applications (continued)

Crop	Year	Pesticide	Acres	Rate (pounds/acre)	Applications per year	Month of application
Pine	2	Chlorothalonil & Benomyl	13	0.5/0.25	9	April-Aug.
Pine	2	Maneb	12	2.4	5	Aug.-Oct.
Pine	2	Dimethoate	4.3	0.5	6	May-July
Pine	2	Fenvalerate	15	0.1	2	June-July
Pine	2	Metalaxyl	7	4.6	1	June
Douglas-fir	2	Oxyfluorfen	5-6	0.5-2.2	1-2	March, Sept.
Douglas-fir	2	Diphenamid	5-13	4-10.5	1-2	April, June
Douglas-fir	2	Bifenox	3-7	3.0	1-2	April, June
Douglas-fir	2	Napropamide	5	1.5	1	April
Douglas-fir	2	Chlorothalonil & Benomyl	13	0.5/0.25	9	April-Aug.
Douglas-fir	2	Chlorothalonil	7	1.5	12	Oct.-March
Douglas-fir	2	Benomyl	19	0.5	1	May
Douglas-fir	2	Diazinon	5	1	2-3	June-July
Douglas-fir	2	DCPA	13	10.5	1-2	April, Aug.
Douglas-fir	2	Metalaxyl	15	4.5	1	Sept.
Douglas-fir	2	Chlorpyrifos	30	1.0	1	Aug.
Douglas-fir	2	Fenvalerate	30	0.1	2	June-July
Douglas-fir	2	DCNA	30	1.0	3	May-Dec.
Spruce	2	Diphenamid	5	4	1	April
Spruce	2	DCPA	1-1.5	9-10.5	2	May-June
Spruce	2	Chlorothalonil	1.5	1	1	Nov.
Spruce	2	Metalaxyl	15	4.5	1	Sept.
Other conifers	2	Napropamide	5	1.5	1	April
Other conifers	2	Chlorothalonil & Benomyl	13	0.5/0.25	9	April, Aug.
Other conifers	2	Diphenamid	13	10.5	1-2	April, Aug.
Other conifers	2	DCNA	13	2	1-2	April, Aug.
Other conifers	2	DCPA	5-13	5.25-10.5	1-2	April, Aug.
Other conifers	2	Benomyl	5-10	0.5-1	3-7	June-Sept.
Other conifers	2	Metalaxyl	15	4.5	1	Sept.
Other conifers	2	Chlorpyrifos	5	1.0	1	Aug.
Other conifers	2	Fenvalerate	5	0.1	2	June-July
Hardwoods	2	Carbaryl	1	0.5	3	April, June, Aug.
Pine	3	Bifenox	18-34	3	4	May-June, Aug.-Sept.
Pine	3	DCPA	5	9	1	April
Pine	3	Chlorothalonil	5	1	10	May-Aug., Nov.
Pine	3	Maneb	12	2.4	5	Aug.-Oct.
Pine	3	Chlorothalonil & Benomyl	0.3	0.5/0.25	9	April-July, Oct.
Pine	3	Diphenamid	1.5	2.2	6	March, May-June, Nov.

Table 3-2--Generic schedule for pesticide applications (continued)

Crop	Year	Pesticide	Acres	Rate (pounds/acre)	Applications per year	Month of application
Douglas-fir	3	Napropamide	1	1.5	1	April
Douglas-fir	3	Chlorothalonil & Benomyl	0.3	0.5/0.25	9	April-July, Oct.
Douglas-fir	3	Bifenox	4-7	3	4	May-June, Aug.-Sept.
Spruce	3	DCPA	0.7-1	9-10.5	2	May-June
Spruce	3	Diphenamid	1.5	2.2	6	March, May-June, Nov.
Spruce	3	Chlorothalonil	1	1	1	Nov.
Other conifers	3	Chlorothalonil & Benomyl	0.3	0.5/0.25	9	April-July, Oct.
Other conifers	3	Diphenamid	7	2.2	6	March, May-June, Nov.
Other conifer	3	DCNA	7	2	6	March, May-June, Nov.
Other conifers	3	Bifenox	18-34	3	4	May-June, Aug.-Sept.

[a]Diazinon 4.25 lb/acre at low acreage only; 0.5 lb/acre at high acreage only.

Table 3-3--Pesticide application rates and acres treated for nursery operations[a]

Pesticide	Average lb a.i./acre (routine-realistic)	Maximum lb a.i./acre (routine-extreme)	Average acres (routine-realistic)	Maximum acres (routine-extreme)
		Herbicides		
Atrazine	2.00	2.00	70.00	70.00
Bifenox	3.00	3.00	17.39	33.00
2,4-D	1.20	1.20	81.00	81.00
DCPA	8.79	10.50	5.72	13.00
Dicamba	1.00	1.00	75.00	75.00
Diphenamid	5.27	10.50	5.36	13.00
Glyphosate	0.26	2.00	50.00	85.00
Napropamide	1.25	1.50	8.00	36.00
Oxyfluorfen	0.61	2.20	33.50	57.50
Sethoxydim	0.40	0.40	85.00	85.00
Simazine	2.00	2.00	15.00	15.00
		Fungicides		
Benomyl	0.42	1.00	14.66	85.00
Captan	1.50	1.50	85.00	85.00
Chlorothalonil	0.93	1.50	8.65	48.00
DCNA	1.41	2.00	12.47	30.00
Maneb	2.40	2.40	11.67	12.00
Metalaxyl	4.52	4.60	11.80	15.00
Triadimefon	0.50	0.50	50.00	50.00
		Insecticides		
Carbaryl	0.62	0.80	1.00	1.00
Chlorpyfiros	1.00	1.00	17.50	30.00
Diazinon	2.25	4.25	19.18	45.50
Dimethoate	0.50	0.50	4.30	4.30
Fenvalerate	0.10	0.10	16.67	30.00

[a]These application rates and number of acres treated are based on the generic nursery pesticide treatment schedule. The maximum pounds per acre is the maximum use rate, not the maximum label rate.

- The resident ate the vegetable immediately after the pesticide residue landed on it without washing or rinsing it.

First, it is standard Forest Service practice to avoid conditions that seem likely to cause drift onto sensitive areas, such as a garden, if one happened to be nearby. Second, there is only a small possibility that the resident would pick and eat a garden vegetable immediately after an application operation. Also, the resident probably would wash the vegetable before eating it. This combination of factors makes the possibility of the resident receiving such a dose remote.

Affected Populations

The populations that could be affected by exposure to the pesticides used in the nurseries can be divided into two groups. The first group, the workers (including both nursery employees and contractors), consists of those persons who are directly involved in the nursery operations, from the application of the pesticides to the outplanting of the nursery stock. The worker group includes the following personnel categories: mixer/loader/applicator, weeder/irrigator, inventory personnel, lifter/sorter/packer, fumigator, tarp lifter, seed treater, benomyl root treater, and tree planter. The second group is the general public, which may be subject to nonoccupational exposure. This group includes the residents (or workers) living at the nursery or in homes just outside the nursery boundary.

Worker Exposures

Table 3-4 lists the pesticides used by the nurseries and the types of worker that may be exposed to each. Table 3-5 lists the number of each type of worker at each nursery.

Workers may be exposed dermally or by inhalation during routine operations, including mixing and loading pesticides into application equipment; applying pesticides to the soil or vegetation; fumigating or removing a fumigant tarp; working in a treated seedling bed soon after pesticide application; or handling seedlings some time after pesticide treatment during tasks such as lifting, sorting, packing, and tree outplanting. Inhalation exposures would be negligible compared to dermal doses (Dubelman et al. 1982), except in the case of exposure to fumigants; therefore, inhalation doses were not calculated for the other types of pesticides.

In general, workers who use protective clothing and equipment and who adhere to proper cleanup procedures, label precautions, and reentry intervals will have significantly reduced doses.

The weeders or inventory personnel (depending on the size of the stock) can be expected to have the highest doses because their contact with the vegetation may occur soon after spraying (2 to 7 days). Lifters, sorters, and packers have considerable contact with foliage, but only after a relatively long time (1 to 2 months), which would in general allow dissipation of most dislodgeable residues.

Table 3-4--Pesticide use and type of worker exposed

Pesticide	Use[a]	Type of worker exposed: Mixer/loader/ applicator	Weeder	Inventory personnel	Lifters, sorters, packers	Tree planters
Herbicides						
Atrazine	A	•				
Bifenox	C	•	•	•	•	•
2,4-D	A,B	•				
DCPA	C	•	•	•	•	•
Dicamba	A,B	•				
Diphenamid	C	•	•	•	•	•
Glyphosate	B,C	•	•	•	•	•
Napropamide	C	•	•	•	•	•
Oxyfluorfen	C	•	•	•	•	•
Sethoxydim	C	•	•	•	•	•
Simazine	B,C	•	•	•	•	•
Fungicides						
Benomyl	C	•	•	•	•	•
Captan	C	•	•	•	•	•
Chlorothalonil	C	•	•	•	•	•
DCNA	C	•	•	•	•	•
Maneb	C	•	•	•	•	•
Metalaxyl	C	•	•	•	•	•
Thiram	C	•	•	•	•	•
Triadimefon	C	•	•	•	•	•
Insecticides						
Carbaryl	B,C	•	•	•	•	•
Chlorpyrifos	C	•	•	•	•	•
Diazinon	C	•	•	•	•	•
Dimethoate	C	•	•	•	•	•
Fenvalerate	C	•	•	•	•	•
Fumigants						
1-3 Dichloropropene	C	•				
Methyl bromide + chloropicrin	C	•				
Vorlex	C	•				

[a] A = Cover crop pest control; B = general nursery control; C = nursery bed pest control.

Table 3-5--Number of workers involved in Forest Service nursery activities (range given for average to maximum)

Nursery	Mixer/loader/ applicators	Inventory personnel	Lifters	Sorters and Packers	Fumigators	Tarp lifters
Albuquerque, NM	1-9	6-9	100-120	100-120	8	6-8
Ashe, MS	10-14	2-2	40-60[a]	20-60[a]	3[a]	4
Bend Pine, OR	2-2	10-12	4-5 20-30[a]	65-68	1 4[a]	3[a]
Bessey, NE	2-4	6-8	15-30	40-50	4	2
Coeur d'Alene, ID	2-3	4-6	100-200	160-300	5 2[a]	3
Humboldt, CA	2-2	4-6	15-30	80-96	4-8 2-3[a]	5-6
Lucky Peak, ID	1-2	7-8	60-95	48-96	6	4
Placerville, CA	1-3	8-8	20-30	43-52	3[a] 2[a]	3-4[a]
Stone, OR	4-4	24-30	20-60[a]	170-190	5-7[a]	3-4[a]
Toumey, MI	1-2	3-4	20-40	40-50	3	3-6
Wind River, WA	2-6	18-24	50-150	120-150	5 2[a]	3-6

[a]Contractor personnel.

The dermal dose to applicators depends on the concentration of pesticide in the spray mix, the surface area of the sprayed person's exposed skin, the extent to which the person's clothing absorbs pesticide (some clothing is water repellent, but other material would permit penetration of the pesticide to the skin), and the time that elapses before the person can wash. Dermal exposure of workers in tasks other than pesticide application depends on reentry time to treated areas and the degree of contact with treated plants and soils.

In the unlikely event of an accident, workers may be exposed to much greater amounts of pesticide than they would under normal circumstances. High dermal exposures would result if pesticide concentrate or some of the prepared spray mixture spilled on a worker's skin during mixing, loading, or spraying operations. A worker who was accidentally sprayed with pesticide because of being too close to a tractor applicator would receive a dermal dose.

Doses were estimated for the following worker categories:

- Mixer/loader/applicators (pesticide application tractor drivers)
- Weeders
- Inventory personnel
- Lifters, sorters, packers, and tree planters
- Fumigators
- Tarp lifters
- Seed treaters
- Root treaters

Mixer/Loader/Applicator

Table 3-6 is a summary of pesticide application times, which shows the likely months during which mixer/loader/applicators could be exposed to each pesticide that may be applied in a nursery. For this risk assessment it is assumed that, in a given nursery, the same personnel apply all the pesticides in any year. Thus, this assumption overestimates exposure and risk. The average number of personnel involved is 2, with a maximum number of 14. No other workers or supervisors are assumed to be directly involved in pesticide applications.

Routine-Realistic. Routine-realistic exposure concentrations are calculated for a given pesticide from the average application rates and average number of acres treated listed in table 3-3. This analysis assumed that the workers did not use any protective clothing and that they treated 40 to 100 acres per day.

Table 3-6--Pesticide application times by month of average programs for each nursery[a]

Nursery	Albuquerque, NM	Ashe, MS	Bend Pine, OR	Bessey, NE	Coeur d'Alene, ID	Humboldt, CA	Lucky Peak, ID	Placerville, CA	Stone, OR	Toumey, MI	Wind River, WA
Herbicides											
Atrazine		June[b]									
Bifenox	July	April	April, Aug.			March, April, June	April, June	May, July	June[c] Sept.	May-June	
2,4-D	April, Sept.[b]						June[c]				
DCPA					May-June	April	May-June				Aug.
Dicamba									April[c]		
Diphenamid						April, Aug.	April	June, Aug.	March, June-July, Sept-Oct., Dec.		
Glyphosate	April-Sept.[c]	May	April-Oct.		June[c] July, Aug.[c]	Feb.-Oct.[c]	April	April-Oct.[c]	Feb.[b] March-Sept.[c]	April-Oct.[c]	June-Sept.[c]	April-Oct.[c]
Napropamide		April				April					
Oxyfluorfen		April Aug., Oct.			June-Aug.		March-April			March-April Sept.-Nov.	
Sethoxydim		May-June									
Simazine		May				June[c]				Sept-Oct.[c]	

Table 3-6--Pesticide application times by month of average programs for each nursery[a] (continued)

Nursery	Albuquerque, NM	Ashe, MS	Bend Pine, OR	Bessey, NE	Coeur d'Alene, ID	Humboldt, CA	Lucky Peak, ID	Placerville, CA	Stone, OR	Toumey, MI	Wind River, WA
Fungicides											
Benomyl (Benlate)		May, July Sept., Oct.		June, Sept.	April, June	May		June	April-Dec.		July, Aug.
Captan	June	April				Jan.-Feb.[d]		May, July, Jan.-March[d]			
Chlorothalonil		June, Aug.		July	April, June	Oct.-May			April-Nov.	May-Aug. Nov.	July, Aug.
DCNA									May-Dec.		
Maneb										Aug.-Sept.	
Metalaxyl			June		Sept.				March-Oct.		
Thiram						April, May[d]		April, May[d]		April, May[d]	
Triadimefon	April-June										
Insecticides											
Carbaryl (Sevin)					June, Aug.					April-Oct.	June-Aug.
Chlorpyrifos									Aug.		
Diazinon		April, July, Aug.									June
Dimethoate										May-July	
Fenvalerate									June-Sept.		

[a]Used to estimate approximate times of exposure for mixer/loader/applicators and seed treaters.
[b]Cover crop.
[c]Non-crop.
[d]Seed treatment.

Doses to workers were calculated based on worker exposure studies that, in most cases, involved pesticides other than those used in the nurseries. Reinert and Severn (1985) list a variety of applicable studies that have been used by EPA's Exposure Assessment Branch. These include data on 34 cases for ground rig drivers, 30 cases for mixer/loaders using wettable powders, 32 cases for mixer/loaders using emulsifiable concentrates, and 21 cases for seed treaters. In extrapolating from these studies, the exposures are assumed to be directly related to the amount of pesticide applied by applicators or handled by mixer/loaders, as suggested by Reinert and Severn (1985).

The doses for mixer/loader/applicators were estimated using the 2,4-D study by Nash et al. (1982), who measured the urinary excretion of 2,4-D of 26 workers involved in ground applications. Samples were collected for 6 consecutive days after a single exposure to 2,4-D. For this risk assessment, the routine-realistic estimates of doses to mixer/loader/applicators were based on the average total exposures (milligrams per kilogram of body weight) of the mixer/loader/applicators in Nash et al. (2.0×10^{-5} mg/kg) corrected for the amount of pesticide applied per day and for dermal penetration rates.

The dermal penetration rate is assumed to be 10 percent (USDA 1984a), except that for 2,4-D, which is 6 percent based on a study by Feldman and Maibach (1974). The value of 10 percent has not been exceeded in most dermal absorption studies, and it has been used as a moderately conservative value by others, including the British government, for risk assessments.

Routine-Extreme. The routine-extreme exposures were based on the upper 95-percent confidence interval for the mixer/loader/applicators from the Nash et al. (1982) study (0.0445 mg/kg). This exposure was then adjusted based on the highest application rate and acreages for each pesticide shown in table 3-3. The dermal penetration rates used are the same as those described for the routine-realistic exposure for the mixer/loader/applicator.

Accidental. Two types of accidental exposures were calculated for these workers: sprays and spills. For accidental spraying, it is assumed that 2 square feet of exposed skin are sprayed at the intended application rate. For a spill, it is assumed that 500 ml of a 4 lb/gal concentrate is spilled on clothing that allows 30 percent of the active ingredient to pass through to the skin, and 100 ml of the concentrate is spilled directly onto the skin (Newton and Norris 1981).

Weeder

Hand and mechanical weeding are used, in addition to pesticides, to control weeds in the nursery. Dose estimates for weeders are based on the level of dislodgeable pesticide residues on nursery stock and the degree of contact that the particular type of work entails.

Doses resulting from vegetation contact were calculated by combining the following:

- An accounting of dislodgeable residues on nursery stock over time, including washoff from irrigation, and pesticide residue decay.

- An accounting of worker activity in nursery beds over time.

- A calculation of the rate of transfer of residues from foliage to a worker.

The first item required knowledge of the rates and timing of chemical application, the rate of degradation of dislodgeable residues, and the rate of pesticide residue washoff from irrigation. The generic schedule (table 3-2) was used to provide information on the timing of applications. Pesticides applied earlier than June of the first year of the growth cycle, which include atrazine, 2,4-D, dicamba, and glyphosate, were considered as preemergent applications and, therefore, doses resulting from vegetation contact were not calculated for these applications.

Calculations of the amount of pesticide washed off from vegetation during irrigation or rainfall were based on the foliar washoff of pesticides (FWOP) model (Smith and Carsel 1984). This model calculates the rate of pesticide loss from foliage using initial pesticide residue values, the specific first-order degradation rate constant for a pesticide on foliage, a washoff coefficient of 10 percent per centimeter of water, and the amount of irrigation water or rainfall received by the crop per day. It was assumed that the beds were irrigated every other day at a rate of 0.33 inches per day. A summary of nursery irrigation practices is listed in table 3-7. Initial residue values were adjusted by a factor of 0.6 based on the dislodgeable fraction used for nonorganochlorine pesticides in the chemical, runoff, and erosion from agricultural management systems (CREAMS) model (USDA 1980, as cited in Smith and Carsel 1984).

A leaf area index for each age class of nursery stock was used to account for the decrease in dislodgeable residue per unit of leaf surface area as the plants increase in size. The leaf area index is the ratio of the amount of leaf surface a plant has per unit of ground surface beneath the plant. The indexes used were conservative. They implied that first-year stock receives the full per-acre application rate on each leaf, but fourth-year stock receives an average of only 57 percent of the full rate on each leaf because of the greater foliage density.

A pesticide's dislodgeable residue decay rate is used when known to represent the time course of dissipation of dislodgeable residues. In cases where the dislodgeable residue decay rate is not known, a degradation coefficient is used that represents the total residue decay rate for residues in or on the plant. The residue decay rates are listed in table 3-8. In general, the decay rate represents a lower limit that underestimates surface residue dissipation because surface residues generally degrade faster than residues in plants, and therefore overestimates doses from vegetation contact.

Worker activity is based on the generic nursery schedule found in table 3-2 and on reentry times to treated beds. Although the practices are realistic, they were chosen to represent relatively labor-intensive nursery

Table 3-7--Irrigation practices at Forest Service nurseries

Nursery	Duration of irrigation (hours)	Inches of water applied	Time between application of soil-active pesticide and irrigation	Time between application of foliar-active pesticide and irrigation (days)
Albuquerque, NM	≤3	0.25	1 month	2
Ashe, MS	1	0.5	≥2 hours	1
Bend Pine, OR	0.75	0.5	30 minutes	NA
Bessey, NE	0.3-0.5	0.25	30 minutes	3
Coeur d'Alene, ID	0.5	0.13-0.14	10 minutes	NA
Humboldt, CA	NA	NA	NA	1
Lucky Peak, ID	0.5	0.1	5-10 minutes	1
Placerville, CA	0.5-2	0.1-0.4	30 minutes	NA
Stone, OR	1-2	0.12-0.25	5-10 minutes	NA
Toumey, MI	0.5-2	≤0.5[a]	10 minutes	1
Wind River, WA	0.5	0.25	<5 minutes	NA

NA = Not available or not applicable.

Table 3-8--Degradation rates of pesticides on vegetation

Pesticide	Degradation rate constant (K)	Half life (days)	Reference[a]
Herbicides			
Atrazine	0.046	15	Montgomery and Freed 1961
Bifenox	0.090	7.7	EPA 1981a
2,4-D	0.043	16	Morton et al. 1967, as cited in USDA 1984a
DCPA	0.025	28	Hurto et al. 1979
Dicamba	0.050	14	Morton et al. 1967, as cited in USDA 1984a
Diphenamid	0.087	8	Lemin 1966, as cited in USDA 1987
Glyphosate	0.050	14	Newton et al. 1984
Napropamide	0.131	5.3	Stauffer Chemical Co. 1985
Oxyfluorfen	0.060	11.6	Vanstone and Stobb 1978, as cited in USDA 1987
Sethoxydim	0.462	1.5	Wills 1984, as cited in USDA 1987
Simazine	0.039	18	Montgomery and Freed 1961
Fungicides			
Benomyl	0.022	32	Baude et al. 1974, as cited in USDA 1986b
Captan	0.052	13	Annapurna and Rao 1980, as cited in USDA 1986b
Chlorothalonil	0.023	30	Gilbert 1976, as cited in USDA 1986b
DCNA	0.198	3.5	Groves and Chough 1970, as cited in USDA 1987
Maneb	0.050	14	Nash and Beall 1980, as cited in USDA 1986b
Metalaxyl	0.099	7	USDA 1987
Thiram[b]	--	--	--
Triadimefon	0.017	42	Rouchard et al. 1981, as cited in USDA 1987
Insecticides			
Carbaryl	0.102	6.8	Smith and Carsel 1984
Chlorpyrifos	0.231	3	Iwata et al. 1983
Diazinon	0.139	5	Ciba-Geigy 1984
Dimethoate	0.124	5.6	Iwata et al. 1979
Fenvalerate	0.533	1.3	USDA 1985d

[a]In most cases a specific degradation rate or half-life was not reported, but it was calculated from residue information given by the author(s).
[b]Not determined, used only for treating seeds in nursery operations.

management. Worker activity is scheduled in terms of the work operation, the date, and the number of hours per day. This information is correlated with the dislodgeable residue estimates to calculate worker doses.

The calculation of absorbed pesticide doses from contact with foliage was done following the procedure used in the "unified field model" (Popendorf and Leffingwell 1982; Popendorf 1985). The unified field model calculates worker doses based on estimates of initial pesticide residue levels, dislodgeable residue decay, and dermal absorption rates of pesticides. Dislodgeable residues were assumed to degrade from the day of application to the day of reentry into a nursery bed. The rate of transfer of residues from foliage to workers was assumed to be equivalent to 1,600 cm^2 of residues per hour.

Routine-Realistic. For the average nursery, a crew of 11 weeders spends 40 days per year pulling weeds. Routine-realistic exposure of weeders is based on average reentry times: 30 days for herbicides and 7 days for insecticides and fungicides. It was assumed that weeders spent 6 hours per day in the treated beds. The fraction of each weeder's time spent in beds treated with a given chemical was assumed to be the same as the fraction of the total nursery bed acreage treated with that chemical.

Routine-Extreme. The maximum number of workers is a crew of 24, weeding for 105 days per year. The routine-extreme exposure for weeders is calculated using the lower estimates for time to reentry, which are 7 days for herbicides and 2 days for insecticides and fungicides. Weeders spend 8 hours per day working in the beds. The other methods used are similar to those described under routine-realistic for weeders.

Accidental. Accidental exposure assumes premature reentry to a bed 2 hours after it has been treated with pesticide, and 8 hours work per day in the treated area. The exposure analysis methods are the same as those described for routine-realistic weeders.

Inventory Personnel

During the year, nursery personnel count a sample of the plants and measure the height and diameter of selected plants in each nursery bed. Table 3-9 is a summary of time intervals between pesticide application and entry into the beds for taking inventory.

Routine-Realistic. The average number of workers involved in this activity is 8 people for 18 calendar days per year. The routine-realistic exposures for these workers are based on the average or realistic number of days between pesticide application and inventory presented in table 3-9. The methods used to calculate foliar residues and dermal exposure are the same as those described for routine-realistic exposures for weeders except that workers were assumed to spend 6 hours per day actually handling foliage.

Routine-Extreme. The maximum number of workers in this activity is 24, working for 30 days per year. Routine-extreme exposures are based on

Table 3-9--Reentry times for inventory personnel

Pesticide	Realistic exposure: Days between pesticide application and inventory	Extreme exposure: Least number of days between pesticide application and inventory
Herbicides		
Atrazine	A	-
Bifenox	24	2
2,4-D	A,B	-
DCPA	35	7
Dicamba	A,B	-
Diphenamid	49	7
Glyphosate	15	10
Napropamide	20	7
Oxyfluorfen	50	2
Sethoxydim	30	5
Simazine	C	-
Fungicides		
Benomyl	29	2
Captan	21	7
Chlorothalonil	22	7
DCNA	7	2
Maneb	C	-
Metalaxyl	21	2
Thiram	D	-
Triadimefon	27	20
Insecticides		
Carbaryl	30	15
Chlorpyrifos	14	7,E
Diazinon	40	20
Dimethoate	14	7
Fenvalerate	7	7
Fumigants		
Dazomet	120	90
1,3-Dichloropropene	120	90
Methyl bromide + chloropicrin	120	90
Vorlex	120	90

Note: A = cover crop pest control, no inventory exposure; B = general nursery pest control, no inventory exposure; C = applied after inventory, no inventory exposure; D = applied to seed before sowing, no inventory exposure; E = with protective gloves.

the lower reentry times found in table 3-9. The analysis was similar to that described for the routine-realistic analysis.

Accidental. Accidental exposure assumes premature reentry 2 hours after spraying. Inventory personnel are assumed to work 8 hours per day in the treated bed. The exposure analysis methods are the same as those described for routine-realistic.

Lifters/Sorters/Packers (Seedling Processors)/Tree Planters

During late fall, winter, and early spring the seedlings are removed (lifted) from the nursery beds, sorted, and packed for shipment to the outplanting site for field planting. These workers have considerable contact with treated foliage, but normally a time interval of 1 to 2 months has elapsed since treatment, during which residues have been washed off or degraded. Tree planters would have dose levels no greater than those of lifters, sorters, and packers, and they could be even less if further degradation of residues occurred. See the discussion on root treaters for more information on tree planters' exposure to benomyl.

Routine-Realistic. For the average nursery, a crew of 115 workers takes 30 days to process all the seedlings for shipment. The routine-realistic exposures for these personnel are calculated for each pesticide using the average number of days between application and seedling processing listed in table 3-10. The methods used to calculate foliar residues and dermal exposure are the same as those described for weeders except that workers were assumed to spend 8 hours per day at these activities.

Routine-Extreme. The routine-extreme seedling processing for a nursery requires 460 workers and 95 working days per year. The routine-extreme exposures for these workers are based on the least number of days between pesticide application and lifting, sorting, and packing activities as presented in table 3-10. The analysis was similar to that described for routine-realistic.

Accidental. Accidental exposure assumed premature reentry to a bed 2 hours after treatment and 10 hours work per day in such beds.

Fumigators

Fumigants are usually applied as a gas or liquid to the soil subsurface by chisel injection. Dazomet is applied in granular form, incorporated into the soil, and the soil wetted and compacted to prevent the escape of dazomet's volatile breakdown products. An average of one third of the total bed acreage of a nursery is fumigated each year. In 1983, the Forest Service nurseries treated 276 acres with fumigants and used 69 workers for an average of 7.3 hours per day for 5.2 days per year (USDA 1986b). In 1985, there were approximately 65 applicators and 50 tarp lifters involved in fumigation of Forest Service nurseries. All but one nursery employed contract crews for fumigating. Table 3-11 provides a summary of fumigation practices.

Table 3-10--Reentry times for lifters, sorters, and packers

Pesticide	Realistic exposure: Days between pesticide application and lifting, sorting, and packing	Extreme exposure: Least number days between pesticide application and lifting, sorting, and packing
Herbicides		
Atrazine	A	-
Bifenox	120	90
2,4-D	A,B	-
DCPA	135	110
Dicamba	A,B	-
Diphenamid	120	120
Glyphosate	80	60
Napropamide	120	120
Oxyfluorfen	105	90
Sethoxydim	120	90
Simazine	135	90
Fungicides		
Benomyl	90	45
Captan	120	90
Chlorothalonil	60	15
DCNA	14	14
Maneb	40	21
Metalaxyl	120	60
Thiram	C	-
Triadimefon	110	110
Insecticides		
Carbaryl	140	90
Chlorpyrifos	120	45
Diazinon	120	120
Dimethoate	120	90
Fenvalerate	120	60
Fumigants		
Dazomet	240	200
1,3-Dichloropropene	240	200
Methyl bromide + chloropicrin	240	200
Vorlex	240	200

Note: A = cover crop pest control, no exposure; B = general nursery pest control, no exposure; C = applied to seed before sowing, no exposure.

Table 3-11--Fumigation practices of Forest Service nurseries

Nursery	Pesticide	Acres	Rate (pounds/acre)	Month or season	Hours between application of fumigant and removal of tarp	Days between tarp removal and reentry
Albuquerque, NM	Methyl bromide + chloropicrin	30	350	June	48	1
Ashe, MS	Methyl bromide + chloropicrin	85	53	March	48	1
	or 1,3-dichloropropene	85	234	March	--[a]	1[a]
	or Vorlex	85	384	March	--[a]	1[a]
Bend Pine, OR	Methyl bromide + chloropicrin	20	350	August	48-72	14-28
Bessey, NE	Methyl bromide + chloropicrin	7.6	350	April, July	72	7
Coeur d'Alene, ID	Methyl bromide + chloropicrin	30	350	August	48-72	2-7
	dazomet	25	350	August	--[a]	5-7[a]
Humboldt, CA	Methyl bromide + chloropicrin	20	320	September	48	7
Lucky Peak, ID	Methyl bromide + chloropicrin	17.5	350-380	September	96	225
	or dazomet	17.5	350	September	--[a]	5-7[a]
Placerville, CA	Methyl bromide + chloropicrin	26	325-400	July	48	5 (2-8)[b]
Stone, OR	Methyl bromide + chloropicrin	45	350-400	September	48-120	180
	dazomet	20	350	September	--[a]	7-180[a]
Toumey, MI	Methyl bromide + chloropicrin	10-15	350	Fall or Spring	72	2
Wind River, WA	Methyl bromide + chloropicrin	55	360	April, September	48-72	2

[a]Immediate reentry during severe rainstorms.
[b]Tarp is generally not used with this fumigant; time listed is for days after treatment.

Routine-Realistic. Fumigants used in nursery operations include dazomet, 1,3-dichloropropene, methyl bromide + chloropicrin (mixed at 98:2 or 67:33), and Vorlex.

Methyl bromide and chloropicrin--Fumigation with methyl bromide + chloropicrin is performed by a crew consisting of a tractor operator, a chaser, and an assistant. The crew members may rotate assignments throughout the workday. Generally, workers do not wear protective clothing. The crew works at a rate of about 1 acre per hour for 8 to 11 hours per day (averaging approximately 10 hours) and may treat 8 to 12 acres in that time.

The tractor is driven at a speed of about 1 mile per hour. The applicator has a treatment width of 12 feet. The chisel blades, approximately 12 inches apart, inject the fumigant into the soil. Behind the injector, a plastic tarp rolls out over the treated soil and is glued to the edge of the adjacent swath of tarp that has been laid down on the previous pass. The outside edge of each strip is covered with soil. At the end of the bed, the chaser cuts the plastic and covers the end with soil.

A 1,000-foot length of bed takes approximately 10 minutes to treat. An additional 2 minutes is required to close the valves, cut the plastic, and turn the tractor around. A new roll of plastic must be loaded on the tractor for every 4,000 feet of bed treated (after approximately 48 minutes). A 15-minute break is taken at this time. Generally after about 3.5 hours of application, the fumigant tank must be exchanged for a full one. The workers take a 45-minute break at this time. Based on this description of fumigation practices, a worker is exposed to fumigants for approximately 5.2 hours out of a 10-hour workday.

Worker exposure studies conducted by Maddy et al. (1982, 1983a, 1984a) were used to estimate exposure concentrations for nursery workers using methyl bromide and chloropicrin. These studies are summarized in appendix I. The measured concentrations in these studies were adjusted to reflect the application rates for methyl bromide and chloropicrin used in nursery operations and the duration of worker exposure to a fumigant during a typical day of nursery fumigation.

The three worker categories described under fumigation practices (tractor operator, chaser, and assistant) are considered comparable to the three categories described in the worker exposure studies (tractor driver, copilot, and shoveler).

Vorlex and 1,3-dichloropropene--Application methods for these fumigants are similar to those for methyl bromide + chloropicrin, except that the soil is compacted over the treated area rather than covered with a plastic tarp. Also, workers use a self-contained breathing apparatus when using these fumigants.

A monitoring study conducted by Maddy et al. (1984b) was used to estimate exposure concentrations for workers using Vorlex or 1,3-dichloropropene. This study is summarized in the appendix. The 1984

study measured higher exposures than had been observed in previous studies (for example, Maddy et al. 1980), so its use may overestimate exposures to some degree. The analysis was similar to that described for methyl bromide + chloropicrin except that the measured concentrations were not adjusted for application rates because no correlation was observed between exposure and application rate. Also, protection factors derived from the studies were used to reflect the decrease in exposure from the use of respirators.

Dazomet--This fumigant is applied to the soil surface with a granule spreader and tilled into the soil to a depth of 8 to 9 inches. Thorough mixing in the soil is achieved using a rotavator or spade. The soil is irrigated daily for 5 to 7 days to ensure activation of the pesticide and to avoid loss of the active gases (MITC and formaldehyde).

Exposure of workers to the breakdown products of dazomet was estimated based on the rate of MITC production in dazomet-treated soil observed by Munnecke and Martin (1964). The data used were obtained using a Greenfield sandy loam soil under conditions favorable to dazomet breakdown. The production of each molecule of MITC is assumed to be accompanied by one molecule of monomethylamine, two molecules of formaldehyde, and one molecule of hydrogen sulfide (Torgeson et al. 1957).

The workers are assumed to be on the downwind edge of a treated field under warm, moist soil conditions and with uniform air temperature. MITC and hydrogen sulfide were assumed to be released rapidly from the soil after their formation, but formaldehyde and monomethylamine were assumed to be released with a half-life of 2 days in soil, without degradation. Some degradation is expected to occur in soil, so that formaldehyde and monomethylamine concentrations in air are expected to be overestimated to some degree.

Accidental. Potential exposure of workers to fumigants by accidental release of gas such as from a leaky hose or a broken blade was estimated with a Gaussian plume model using Pasquill atmospheric turbulence types (Hanna et al. 1982; Pasquill 1974). Turbulence types are based in part on surface wind speed and amount of sunlight.

Evaporation rates for 1,3-dichloropropene, methyl isothiocyanate, and chloropicrin were estimated from calculations based on equations in Drivas (1982). The calculations used the vapor pressure and molecular weight of the fumigant, the ambient temperature, wind speed, and diameter of the spill. Air temperature was assumed to be 60 °F, wind speed was 5 mph, and the diameter of the spill was 1 m.

The estimated evaporation rates were then input to the plume model. The application rates used in the model were 350 lb/acre for methyl bromide + chloropicrin (assuming 2 percent or 33 percent chloropicrin), 234 lb/acre for 1,3-dichloropropene, and 384 lb/acre for Vorlex. Tractors were assumed to apply the fumigant while moving at 1 mph. Exposures were estimated for distances of 5, 25, and 100 feet downwind of the spill. Accidental exposures were not calculated for dazomet. Because of its granular form, a spill of dazomet would not pose an immediate inhalation hazard.

Tarp Lifters

Tarp lifters wait approximately 24 to 72 hours after application of the fumigant to remove the protective tarp. Workers generally reenter the field from 1 to 7 days after removal of the tarp. The Lucky Peak and Stone nurseries have much longer time periods before reentry: 225 and 180 days, respectively. Approximately 15 acres of tarp may be removed per day. In 1985, there were approximately 50 tarp lifters involved in nursery operations.

Routine-Realistic. Methyl bromide exposures for tarp lifters were estimated from the monitoring study by Van Den Oever et al. (1982), which is described in appendix I. These exposures averaged 14.7 ppm. However, these results and the higher values measured during fumigation of bowling greens (Simpson 1967, as cited in USDA 1986b) indicate that short-term concentrations may reach several hundred ppm.

Seed Treaters

Some nurseries may treat their pine and fir seeds with fungicides before they are sown. Thiram has been used at Placerville Nursery (3,694 pounds of seeds in 1 year) and the Toumey and Humboldt nurseries. Captan has also been used at Placerville (3,357 pounds of seeds in 1 year) and at Albuquerque and Humboldt. The other nurseries did not report any type of seed treatment. Thiram and captan seed treatments are described briefly below.

Regarding thiram, the EPA-approved label includes the following precaution for thiram seed treatment: "wear goggles, clean rubber gloves, protective clothing, and a pesticide respirator."

Within 24 hours before sowing, the seed is coated with undiluted thiram. The seed is added to a polyethylene bag that contains thiram; the bag is closed and then rolled by hand until the seed is evenly coated. The coated seed is then spread on screens and placed in a forced-air drier. After the seed has dried, it is coated with talc or aluminum powder for greater durability and returned to polyethylene bags or plastic tubes that are emptied into the seed-drill hopper at the time of sowing.

The Humboldt Nursery has estimated a total application exposure time of at least 8 hours per day for 5 to 7 days per year.

In the captan seed treatment process, captan (50WP) wettable powder is combined with enough water to make a thin liquid suspension of 5 gallons total volume. For all nurseries using captan, applicators wear goggles, respirator, hat, rubber gloves, coveralls, and rubber boots while preparing the slurry. Assistants wear goggles, rubber gloves, coveralls, and rubber boots.

Up to 3.5 pounds of seeds are put into nylon mesh sacks. These sacks are then dipped into the slurry several times until all of the seeds have been coated. The sacks are hung to drain and then enclosed in polyethylene bags for stratification. Seeds are stratified 45 to 90 days following

treatment with captan. They are then emptied from the sacks and air-dried. Employees wear rubber gloves while handling the seeds.

The Humboldt Nursery has estimated a total application exposure time of 2 to 4 hours per day for 7 to 10 days per year.

Routine-Realistic and Routine-Extreme. Exposures of grain seed treaters to thiram have been studied by Grey et al. (1983). In this study, carboxin was applied together with thiram at eight different sites including a range of operations from very small to large commercial facilities. Exposures were measured by sampling pads on chest and arms, and by ethanol hand rinses. In no case was thiram detected on chest or arms. When gloves were worn, as required in Forest Service nursery operations, thiram was not detectable on the hands. Therefore, for this analysis it was assumed that during routine operations no detectable exposure to thiram would occur. The same was assumed to be true for captan.

Accidental. The study by Grey et al. (1983) described above was also used to estimate accidental exposure to seed treaters. The study showed that when seeds were handled with bare hands, thiram exposures ranged from 1.34 to 3.70 mg per hour. The mean exposure for four such sites was 2.45 mg per hour. An 8-hour workday and 10 percent dermal absorption were assumed for a 70-kg worker who did not follow required precautionary procedures. The exposure to captan was estimated similarly.

Root Treaters

In the Ashe Nursery, the roots of longleaf pine seedlings are treated before storing and outplanting with a slurry mixture of the fungicide benomyl and kaolin clay. About 500 seedlings are first packed into plastic-lined breathable paper bags. The slurry is then applied by inserting hose into the bags. The applicator must wear rubber gloves and an apron during this procedure. The bags are then sealed and kept in cold storage at a temperature of 34 °F until the time of outplanting. Any residues on the trees at the time of lifting and packing will also be available to the seedling outplanter. The calculation used overestimates exposure because it assumes that no degradation will occur under refrigerated conditions and that the plants are immediately refrigerated after treatment.

Routine-Realistic and Routine-Extreme. The protective clothing worn by the benomyl applicator can be expected to prevent any significant exposure during the operation.

Workers involved in tree planting have some opportunity for exposure to the benomyl used to treat the roots of pine seedlings. Tree planters typically wear cloth gloves, so that contact would be minimal in most cases.

Accidental. In the event of accidental contact by root treaters with the slurry, for example, accidentally spraying a worker's pants legs, the resulting exposure is expected to be much less than for the other pesticide mixtures discussed in this analysis because the kaolin in the slurry is a very good adsorbent. The slurry form of application also makes

inadvertent exposures unlikely because the applicator is fully aware of the location of the slurry.

If tree planters handled benomyl-coated stock with bare hands, some exposure would occur. An indication of the magnitude of exposure is given by the daily doses calculated for workers like weeders who work in treated nursery beds soon after benomyl is applied.

Worker Lifetime Doses

The lifetime doses for mixer/loader/applicators were estimated using the generic schedule values for the total number of acres treated with a specific pesticide (table 3-2). This number was divided by 60, assuming an average of 60 acres are treated per day, to give an estimate of the number of days of exposure per year for each pesticide. Annual doses were then multiplied by 5 years or 30 years to indicate cumulative exposures.

The total time worked by weeders, inventory personnel, and lifters, sorters, and packers were estimated assuming that 95 percent of the time they worked the average number of days per year indicated in the worker-specific descriptions and 5 percent of the time they worked the maximum number of days per year. The fraction of each worker's time spent in exposure to a given chemical was assumed to be the same as the fraction of the whole nursery bed acreage treated with that chemical. This may overestimate exposure because it assumes that workers always work in treated beds and enter at the average reentry interval. The fraction of time spent in beds treated with the specific chemical was multiplied by the number of days worked per year and the daily dose to estimate an annual exposure. This was adjusted for cumulative periods of 5 and 30 years.

Exposures to the Public

Members of the public could be exposed to nursery pesticides through dermal and dietary routes, and to fumigants via inhalation. (They could also be exposed to pesticides by purchasing and planting surplus nursery stock, but such exposure would be no greater than that of a tree planter, and it would likely be much less because tree planters typically plant 800 to 1,000 trees per day, whereas members of the public would probably plant a total of no more than 1,000 trees per year.) This section describes the methodology used to estimate residue deposition to skin, water, and vegetation resulting from spray drift; residues in water from leaching; residues in water from runoff; and exposure to fumigants. It also describes exposure scenarios that represent typical dietary and dermal exposures to members of the public. (The estimates based on these scenarios are presented in table 3-21, which is found later in this chapter.)

Exposure of the public depends on the proximity of the treated nursery beds to residences, garden crops, livestock, drinking water supplies, and streams and other bodies of water that may support aquatic species. Members of the general public who are within the area of drift of the smaller spray droplets may be exposed but, because all nurseries apply pesticides no more than 30 inches above the ground, exposure from drift would be minimal.

Pesticide may be ingested by members of the general public from food containing pesticide residues. Food items such as garden vegetables may have received some level of pesticide from spray drift. Small game animals may have been dermally exposed in the nursery beds by moving among the seedlings after a pesticide treatment. The time between exposure of these game animals and their being killed and eaten, and the preparation of the meat itself by cooking, should greatly reduce any pesticide residues. Public oral doses could also result from eating beef from cattle that have fed on contaminated grass in a nearby pasture, but these potential exposures would be very small because of the small amount of drift associated with nursery operations.

It is also possible (although highly improbable) that the public could ingest pesticides from drinking water that has received pesticide drift, runoff from a treated bed, or ground-water contamination from leaching. The latter would be true only for those pesticides that have a significant potential to leach.

In all but one nursery there is a residence on the nursery site or within 100 feet of the nursery boundary (table 3-12). This analysis assumes a residence at a 100-foot distance. It also assumes that the residents have a vegetable garden located near their house that could receive pesticide drift.

The nurseries are intensively managed sites with very little cover suitable for birds and wildlife. Most of the nurseries are also fenced to exclude wildlife (table 3-13). However, small animals such as rodents, rabbits, and birds may frequent the nursery beds. Many species of birds, for example, robins, sparrows, doves, quail, grouse, and geese, visit the nurseries. These birds may be exposed to pesticides by moving through a treated seedling bed or by eating seed treated with thiram or captan between sowing and germination. Although the possibility of the public eating game that could contain pesticides is very remote, calculations were developed to estimate the levels of possible contamination in rabbits and grouse as possible human diet items.

Most nursery beds are more than 100 feet from open water such as creeks and rivers, with a minimum of 20 feet (drainage ditch at Wind River) and a maximum of approximately 5 miles. More than half of the nurseries are located above aquifers. The closest aquifers are 10 to 15 feet at the Bessey Nursery and 50 feet at the Wind River Nursery (table 3-14). Therefore, the possibility of the public drinking surface water or ground water containing one of the more mobile pesticides has been examined in this analysis.

Pesticide Spray Drift

The results of drift simulations indicate that less than 0.35 percent of the onsite rate of deposition could be deposited at 25 feet from the edge of a treated nursery bed. Only 0.22 percent could be deposited at a distance of 100 feet.

Table 3-12--Nursery residences and boundary information

Nursery	Forest Service residences on site	Residences within 100 Feet	Residences within 200 Feet	Distance to nearest residence if beyond 200 feet (ft)	Land bordering nursery (feet of border)					
					Residential	Forest	Farm-ranch	Orchard	Rangeland	Other
Albuquerque, NM	1	0	0	15,840	0	0	0	0	0	16,200[a]
Ashe, MS	1	0	0	2,700	0	26,400	0	0	0	600[b]
Bend Pine, OR	0	0	4	--	5,280	0	5,280	0	1,980	0
Bessey, NE	6	3	3	--	975	1,225	1,950	0	1,400	0
Coeur d'Alene, ID	2	17	29	--	8,820	4,407	0	0	0	0
Humboldt, CA	1[c]	1	2	--	0	5,000	8,200	0	0	0
Lucky Peak, ID	3	3	0	--	200	0	400	0	11,300	0
Placerville, CA	0	4	4	--	2,500	1,100	4,800	5,750	0	0
Stone, OR	0	9	1	--	1,935	0	16,800	0	0	0
Toumey, MI	1	3[a]	0	--	400	NA[d]	0	0	0	0
Wind River, WA	10	16	2	--	0	20,000	0	0	0	0

[a]Kirtland AFB, Zia Gun Club, City of Albuquerque, University of New Mexico.
[b]Forest Service residence.
[c]Not occupied.
[d]Southern and eastern boundaries, length not available.

Table 3-13--Fencing of nursery boundaries for wildlife

Nursery	Fencing	
	Large animals	Small animals
Albuquerque, NM	No	Yes
Ashe, MS	Yes	No
Bend Pine, OR	Yes	Yes
Bessey, NE	Yes	No
Coeur d'Alene, ID	Yes	Yes
Humboldt, CA	Yes	No
Lucky Peak, ID	Yes	Yes
Placerville, CA	Yes	Yes
Stone, OR	Yes	Yes
Toumey, MI	No	No
Wind River, WA	Yes	Yes

The analysis of pesticide drift beyond 25 feet (near field) and beyond 100 feet (far field) was based entirely on published data derived from field tests of tractor spray systems (Yates et al. 1978; Byass and Lake 1977). In the study by Yates et al., glyphosate was applied to a flat, dry field of short grass and deposition was measured by means of Mylar fallout sheets placed at various distances downwind. Yates et al. presented regression curves that represent deposition from one long swath of spray. To use these data to estimate spray drift from nursery beds, a computer program was written to show how the residues accumulated from multiple swaths. The program also corrects for application rates and swath widths that differ from those used in the Yates et al. study.

Byass and Lake (1977) measured deposition during field tests of ground sprayers using a dye tracer. Data from two of the tests were used to calculate regression equations that could be input to the same computer program used to analyze the Yates et al. test results. One of these equations, representing a relatively high drift situation, gives predictions that are about twice as high as shown by the Yates et al. (1978) test. However, the windspeed ranged from 10.6 to 15.5 mph during Byass and Lake's test. A regression equation computed for less extreme conditions--with 9-mph winds--predicts about the same degree of drift as in the Yates et al. test.

Table 3-14--Soil and water information for Forest Service nurseries

Nursery	Distance to nearest live water (feet)	Type of live water	Aquifer under Nursery	Depth to aquifer (feet)	Nursery soil type	Depth to bedrock (feet)
Albuquerque, NM	26,400	River	Yes	340	Sandy loam	400
Ashe, MS	10,500	Creek	Yes	120	Sandy loam	>1,000
Bend Pine, OR	175	Irrigation ditch	Yes	750	Loamy sand Sand	1-3
Bessey, NE	100	River	Yes	10-15	Sand	Several hundred
Coeur d'Alene, ID	10,000	River	Yes	250	Sandy loam-loamy sand	350
Humboldt, CA	700	Creek	No	-	Fine sandy loam	--[a]
Lucky Peak, ID	350 100	Reservoir Stream	No	-	Heavy silt loam to sandy loam	6
Placerville, CA	600	Springs	No	-	Aiken clay loam	10
Stone, OR	25	Creek	No	-	Sandy loam	>20
Toumey, MI	150	Small stream	No	-	Loam sand & sand loam	--[a]
Wind River, WA	20 100	Drainage ditch Creek	Yes	50	Stabler shotty loam	15-60

[a]Information not available.

Residues on plants resulting from offsite pesticide drift were estimated in a two-step procedure. First, residues were calculated for short grasses based on a regression equation given in Yates et al. (1978) relating deposition on young wheat plants to deposition on mylar sampling sheets. Then the deposition was estimated for other types of plants using relative factors given by Hoerger and Kenaga (1972). These factors are based on a large number of residue sampling studies that showed the effect of varying vegetative yield, surface to mass ratio, and plant interception. Typical values were calculated to represent realistic yet moderately conservative estimates, and upper limit values were calculated to represent possible extremes above the 95-percent probability limit.

Pesticide Leaching Potential

The potential for each pesticide to leach into ground water was examined, and detailed calculations were made for those pesticides that may move even a moderate extent into the soil. The expected vertical distribution and leaching potential were analyzed using a one-dimensional mathematical model in conjunction with physical-chemical parameters obtained from the literature (table 3-15). The leaching simulation provided graphs of pesticide concentration in relation to depth in the soil and tables of fractions of the pesticides in each centimeter increment of soil.

The principal chemical property considered by the model is the adsorption coefficient (Kd). A linear adsorption isotherm is assumed, indicating that the amount adsorbed is directly proportional to the concentration in solution. The model was originally intended to represent freely reversible equilibrium adsorption. This is a good approximation, for example, for 2,4-D, but glyphosate does not meet those conditions. Consequently, for glyphosate, the model was used only to calculate concentrations at early time periods when adsorption predominates and desorption is unimportant. This presented no problem for the analysis, because leaching for glyphosate has been shown by field and laboratory studies to be minimal.

Adsorption coefficients on sandy loam soils were available in the literature for some of the nursery pesticides. For the other chemicals, Kd values were estimated from a review of studies of soil mobility factors (R_f values). Generally, the higher the Kd value, the more strongly adsorbed the pesticide is to the soil and the less likelihood there is for leaching into the soil column. The R_f values given in table 3-15 indicate the relative mobilities of the pesticides in soil thin-layer chromatography tests. In the range of values considered, R_f is almost inversely linearly related to Kd (correlation coefficient 0.94 for sandy loam), and missing values for some chemicals were estimated on that basis. The most mobile of the nursery pesticides are dicamba (R_f = 1.00, Kd = 0.001), napropamide (estimated R_f = 0.94, Kd = 0.27), diphenamid (R_f = 0.94, estimated Kd = 0.21), and 2,4-D (R_f = 0.94, Kd = 0.55). The fumigants are generally highly mobile, but they are lost predominantly to the atmosphere, so leaching was not simulated for these chemicals.

Table 3-15--Leaching potential of nursery pesticides in sandy loam or similar soil type

Pesticide	Kd[a]	Rf[a]	Half-life (days)	Fraction leaching[b]
Herbicides				
Atrazine	0.89	0.81	64	<0.01
Bifenox	8.1[c]	0.50	10.5	NS[d]
2,4-D	0.55	0.94	28	<0.01
DCPA	--	--	30	--
Dicamba	0.00	1.00	25	0.11
Diphenamid	0.21[c]	0.94	135	0.22
Glyphosate	16.5	0.03[c]	61	NS
Napropamide	0.27	0.94[c]	70	0.02
Oxyfluorfen	--	--	35	--
Sethoxydim	6.3[c]	0.60	7	NS
Simazine	1.3	0.88	80	NS
Fungicides				
Benomyl	6.3[c]	0.19	0.35	<0.01
Captan	4.4[c]	0.39	21	NS
Chlorothalonil	8.1[c]	0.00	28	NS
DCNA	8.0[c]	0.01	--	--
Maneb	5.0[c]	0.33	42	NS
Metalaxyl	0.9	--	24	NS
Thiram	1.1[c]	0.73	21	NS
Triadimefon	19.4	0.00[c]	90	NS
Insecticides				
Carbaryl	2.2	--	1	NS
Chlorpyrifos	720	--	89	NS
Diazinon	4.8[c]	0.34	39	NS
Dimethoate	0.21	--	9	NS
Fenvalerate	6.4	--	48	NS

Sources: USDA 1984a; Ghassemi et al. 1981; Helling et al. 1974; Dean et al. 1984; Bache and Liske 1966; Marshall and Roberts 1978; USDA 1985b,c,d; USDA 1986b; USDA 1987.

[a]Determined for sandy loams in most cases; when values were not available for sandy loam, silty clay loam values were used.

[b]Estimated from Leaching Evaluation of Agricultural Chemicals (LEACH) Handbook (Dean et al. 1984). Fraction leaching is what escapes the root zone 10 percent of the time; that is, 90 percent of the time the fraction would be less than that indicated. Fractions could not be calculated for chemicals where a Kd or half-life was not available.

[c]Estimated by regression.

[d]NS = not significant.

A one-dimensional solute transport equation was used to approximate the movement of the pesticides through soil profiles. A computer program was written to solve the transport equation and to integrate it over 1-cm segments. The output of the program includes a table of the pesticide content for each centimeter of soil expressed as a fraction of the total for each time selected.

The results of the leaching model simulation, assuming 2 inches of water percolated into the soil within 24 hours, indicate that no significant residues of any nursery pesticides are expected to reach ground-water supplies because they are at least 10 feet below the surface of any nursery beds. Dicamba has the greatest potential for leaching, and its concentrations would be highest (59 ppb) at a depth of 3 to 5 cm and decline steadily with depth. At 10 cm, concentrations would be only 43 ppb.

In order to verify the minimal potential for leaching of the pesticides used in Forest Service nurseries, an independent methodology developed for EPA was used to calculate leaching frequency graphs for selected chemicals. The leaching evaluation of agricultural chemicals (LEACH) methodology was developed to assess potential pesticide leaching beyond the crop root zone in major agricultural areas of the United States (Dean et al. 1984). The LEACH methodology predicts the frequency of such leaching based on 25-year simulations using EPA's pesticide root zone model (Carsel et al. 1984). The major factors considered include the rate of degradation (half-life) and adsorption of the pesticide, climatic factors, and soil characteristics.

The LEACH methodology was applied to chemicals of low, moderate, and high mobility assuming average soil characteristics for sandy loams. Nursery soils are typically in hydrologic soil group B, indicating a moderately low runoff potential. Tree nursery practices were not specifically considered in the development of the LEACH methodology, so the model of a corn growing area of the midwest, "site no. 10," was chosen as representing a typical row crop situation. The root zone depth for corn is 90 cm.

The results of the LEACH analysis are presented in table 3-15 as the "fraction leaching," that is, leaching beyond the root zone 10 percent of the time. Ninety percent of the time the fraction would be less than the estimated fraction in the table. The frequency of significant leaching of chemicals with low leaching potential, such as chlorothalonil, or moderate leaching potential, such as sethoxydim, is essentially zero. Chemicals with a relatively high leaching potential have some measurable but still small probability of leaching beyond the root zone. For example, the fraction of 2,4-D expected to leach beyond the root zone 10 percent of the time is less than 1 percent. The most mobile of the pesticides is dicamba, with a Kd of near zero and an R_f near 1. Even in this extreme case, the fraction of dicamba leaching beyond the rooting zone 10 percent of the time is only 11 percent of the applied amount. Diphenamid is also highly mobile with an R_f of 0.94. The fraction of diphenamid leaching below the root zone is 22 percent of the amount applied. It should be noted that the diphenamid that leaches below the rooting zone will continue to be diluted and degraded so that concentrations reaching the water table would be

reduced considerably. Furthermore, all wells used for drinking supplies are at a considerable distance from the nursery beds (horizontally and/or vertically) (table 3-14).

In the Bessey Nursery, the depth to the aquifer is only 10 to 15 feet (table 3-14). The sandy soil type poorly adsorbs pesticides; therefore, there is some potential for the more mobile pesticides, such as dicamba and diphenamid, to reach the aquifer. However, there are no wells in the area of the Bessey Nursery and so there is no risk to drinking water supplies. There is only one domestic well within 100 feet of any nursery bed (Ashe Nursery), and annual testing has not yielded any evidence of pesticide residues.

Based on the two methods of analysis discussed above, it was concluded that pesticides used in the nurseries do not pose any risk of significant contamination for human ground-water drinking sources.

Dietary Exposure

The following are exposure scenarios that are representative of typical dietary exposures to the public:

- Eating 0.5 kg of a garden vegetable (lettuce) with drift residue.
- Eating 0.5 kg of beef from cattle grazing in nearby pastures.
- Eating 0.5 kg of a rabbit or grouse that has been dermally exposed in a treated seedling bed.
- Drinking 2.0 liters of surface water that receives drift.
- Drinking 2.0 liters of surface water that receives runoff.

Routine-Realistic. All of the exposures were examined for a distance of 100 feet from treated nursery beds.

Eating a garden vegetable--Pesticide doses to individuals were calculated assuming that no pesticide degradation in vegetables occurs between the time of application and the time of exposure. The method described previously for estimating pesticide residues on plants was used for the garden vegetable (Hoerger and Kenaga 1972).

Eating beef from cattle--Cattle (body weight 550 kg) were assumed to eat 12 kg of grass per day for 5 days and retain 10 percent of the total ingested pesticide. The residues on the grass are assumed to degrade over the 5-day period.

This method of determining human doses from animals that may have absorbed one of the nursery pesticides tends to greatly overestimate the likely doses because it is assumed that no degradation occurs in animals and because animals rarely retain this high level of residue in their tissues.

In tests on laboratory animals with radiolabeled pesticides, a high percentage of pesticides was rapidly metabolized and eliminated in the feces and urine. From 95 to 100 percent of the radioactive dose of the pesticides benomyl, carbaryl, chlorothalonil, dicamba, DCNA, and sethoxydim was eliminated by rats within 72 hours (USDA 1986b; Dolinger and Fitch 1979; EPA 1984h; EPA 1984e; EPA 1984m); 85 to 94 percent of radiolabeled bifenox, captan, maneb, DCPA, 1,3-dichloropropene, diphenamid, and simazine was eliminated in the urine and feces of rats within 96 hours (EPA 1981a; Hoffmen et al. 1973, as cited in EPA 1985g; USDA 1986b; Gutenmann and Lisk 1966; EPA 1985h; NLM 1984; USDA 1984a); 70 to 84 percent of radiolabeled glyphosate and atrazine was eliminated in the urine of test animals within 120 hours (USDA 1984a; EPA 1968). There was a minimal amount of retention in the tissues of test animals.

Eating a rabbit or grouse--A game animal (1.35-kg rabbit) and a game bird (0.75-kg grouse) were assumed to get a dermal residue level equivalent to that on vegetation over 60 percent and 63 percent of their body surfaces, respectively. Penetration of the residue was assumed to be the same as through human skin. The rabbit and grouse were also assumed to get an oral dose from their nonabsorbed dermal residue by grooming 37 and 20 percent of their body surfaces, respectively. Of each animal's total dermal and oral dose, 10 percent was assumed to be retained in the animal's flesh.

Drinking surface water with drift--Surface drinking water was assumed to come from a body of water 2 feet deep, before any dilution has taken place.

Drinking surface water with runoff--Runoff of herbicide from the soil surface was estimated by using a modification of the Haith (1980) model. The model was originally validated using pesticide runoff data derived from tests conducted in Georgia. The model considers adsorption, degradation, and leaching (via the model discussed in the section on leaching) to calculate a mass balance of herbicide in the top centimeter of soil. The herbicide in the surface soil is apportioned to adsorbed and dissolved phases, which are then available for loss as soil and water run off the treated plot. Runoff is calculated on a storm-by-storm basis. Runoff of both sediment (erosion) and water are calculated using standard Soil Conservation Service techniques (USDA 1972).

Erosion was calculated using the universal soil loss equation (Wischmeier and Smith 1978). This equation was designed to predict average soil loss in runoff for specific soil, topographic, and vegetation conditions. The equation is based on a large amount of research data and has a long history of use. The Soil Conservation Service has given ample guidance on the selection of numerical values for the various factors in the equation (Wischmeier and Smith 1978, and a variety of regional publications). Two additions to the equation have been made in the runoff model. First, rainfall erosivity has been calculated on a single-storm basis. Second, provision has been made for the addition of a sediment delivery ratio factor to represent the fraction of sediment leaving a field that actually reaches a receiving water body. Any buffer area between treated beds and drainage channels, but especially a well-vegetated buffer

area, will substantially reduce the amount of eroded sediment reaching the channel. Sediment delivery ratios also generally decrease as the size of the drainage area increases (EPA 1973). The example presented assumes a sediment delivery ratio of 0.5.

The volumes of runoff water were calculated by means of the Soil Conservation Service runoff curve number technique. Runoff curve numbers describe the tendency for rainwater to run off the land. The SCS National Engineering Handbook (USDA 1972) provides guidance on the choice of runoff curve numbers. A runoff curve number of 78 was used to represent typical nursery conditions, which include straight row crops and good hydrologic conditions.

Calculations have been added to the model to estimate the resulting concentrations in a nearby stream that catches the runoff. The assumptions used for this scenario are intended to show the highest concentrations that could reasonably be expected to occur in a stream. The basic assumptions of the stream scenario are the following: the stream is 2 feet deep, the watershed is 500 acres in area, 40 acres of the watershed are treated with the pesticide, intervening land or drainage channels reduce the adsorbed pesticide load by one-half (sediment delivery ratio = 0.5), and processes within the stream, including degradation of the pesticide and sorption to bottom sediments, are not considered. Only the initial concentration has been calculated here.

The results of the runoff model simulation for pesticide concentrations in a nearby stream ranged from 1.4 ppb for DCNA to 8.9 ppb for dicamba.

Sample runoff levels are presented in this section for a base case in which 2 inches of rain are assumed to fall within a 24-hour period starting within 1 day after application of the pesticides. Table 3-16 shows the model output for 2,4-D in the base case. 2,4-D is carried predominantly in solution, and it reaches a concentration of 5.8 ppb in the stream.

Routine-Extreme. All calculations for the five scenarios for routine-extreme dietary exposure used drift depositions at 25 feet rather than 100 feet. All other methods were the same as those described for routine-realistic.

Dermal Exposure

Two scenarios were chosen as representative of potential dermal exposures to the public: direct dermal exposure to spray drift and petting a dog with pesticide residue on its fur.

Dermal exposure was estimated for nearby residents assuming that they are directly downwind of a bed at the time of spraying--at a distance of 100 feet for the realistic case or 25 feet for the routine-extreme case. Spray drift was assumed to contact 2 square feet of exposed skin, and skin penetration was assumed to be 10 percent except in those cases for which chemical-specific penetration rates were known.

Table 3-16--Runoff model results for 2,4-D

PI = 93.69218 theta = 0.4 KAD = 0.49 rho = 1.3 CN = 78
R = 10.029 K = 0.17 LS = 0.367 C = 0.5 P = 1
KLSCP (soil loss factor) = 0.031195
Soil loss = 0.77 tons per hectare
After a rainfall of 2 inches, runoff was 0.48 inches
Sediment concentration is 6,455.7 mg/l
Rate = 1,120 g/ha Half-life = 28 days Time of runoff = 1 day
Fraction of chemical intercepted by vegetation = 0.3
Fraction of chemical in soil occurring in top 1 cm = 0.1225

Edge-of-field concentrations:
PX = 0.342 g/ha = 487 ppb on sediment
PQ = 8.753 g/ha = 71 ppb in solution
Total chemical concentration in runoff 74 ppb

Stream scenario calculations:
Stream depth = 24 in. SDR = 0.5
Watershed area = 500 acres Fraction of watershed that is treated = 0.08
Concentration in stream = 5.79 ppb

Soil type: Tifton sandy loam

PI = Initial pesticide level in soil (needs unit)

theta = available soil moisture capacity (cm/cm)

KAD = adsorption coefficient (mg/kg)/(mg/l)

rho = soil bulk density (g/cm^3)

CN = runoff curve number

R = rainfall and runoff factor

K = soil erodibility factor

LS = slope length, slope steepness factor

C = cover and management factor relating to soil loss under specific vegetation and management conditions

P = support practice factor, representing practices that may reduce ero

PX = adsorbed pesticide lost in runoff (g/ha)

PQ = dissolved pesticide lost in runoff (g/ha)

SDR = sediment delivery ratio

Maximum indirect dermal exposure was estimated assuming that a pet dog is exposed to pesticide by passing through a treated bed and picking up the pesticide on its fur. Half of the residue level on the animal's fur is assumed to be transferred to a person's hand, and a fraction of that subsequently absorbed.

Inhalation Exposure

Routine-Realistic. Routine-realistic exposures of nearby residents to fumigants were estimated from field monitoring studies except in the case of dazomet breakdown products. Exposures to dazomet products were estimated using the same procedure as for dazomet exposures to workers.

Maddy et al. (1983b) measured concentrations of methyl bromide and chloropicrin 25 feet downwind of an application site. The average of 18 samples was 320 ppb for methyl bromide (range ND to 634 ppb) and 52.1 ppb for chloropicrin (range ND to 106 ppb).

Exposure concentrations for 1,3-dichloropropene were also estimated from field monitoring studies. Maddy et al. (1980) measured 1,3-dichloropropene at 100 feet downwind of the application site. At the time of application, the atmospheric concentration downwind was 53 ppb and was slightly higher after 24 hours (60 ppb) and 48 hours (58 ppb).

Accidental. Accidental exposures of nearby residents were estimated for persons at 25 feet and 100 feet downwind of a spill 1 meter in diameter. The Gaussian plume model was used in the analysis as described for the accidental exposures of fumigators.

Public Lifetime Doses

Lifetime doses to the public were calculated by multiplying individual doses by 5 or 30 exposures.

EXPOSURE ANALYSIS RESULTS FOR A GENERIC NURSERY

This subsection presents the results of the exposure analysis. Doses to workers and the public estimated for routine operations and for accidents are summarized and discussed. The calculated doses are based on the generic schedule for applications and are presented in tables 3-17 to 3-21.

Doses to Workers

Mixer/Loader/Applicator

The doses to the mixer/loader/applicator are presented in table 3-17.

Weeders, Inventory Personnel, Lifters, Sorters, Packers, and Tree Planters

The doses to other types of workers including weeders, inventory personnel, and lifters are given in table 3-18. These doses are based on the realistic (average) and extreme (below average) reentry times in

Table 3-17--Doses to mixer/loader/applicators based on the generic application schedule (mg/kg)

Pesticide	Routine		Accidents	
	Mean	Extreme	Spray	Spill
Mean Schedule				
Atrazine	0.0560	0.1300	0.8300	240.0
Oxyfluorfen	0.0079	0.0180	0.2800	120.0
Simazine	0.0120	0.0270	0.8300	240.0
Dicamba	0.0150	0.0340	0.2100	240.0
Glyphosate	0.0073	0.0160	0.3400	180.0
2,4-D	0.0230	0.0520	0.3000	140.0
Napropamide	0.0037	0.0082	0.3900	120.0
DCPA	0.0210	0.0470	3.7000	360.0
Bifenox	0.0110	0.0250	1.1000	120.0
Sethoxydim	0.0140	0.0300	0.1700	92.0
Diphenamid	0.0097	0.0220	2.2000	0.0
DCNA	0.0080	0.0180	0.4200	0.0
Triadimefon	0.0038	0.0084	0.2100	0.0
Chlorothalonil	0.0039	0.0086	0.4600	360.0
Benomyl	0.0024	0.0054	0.1800	0.0
Captan	0.0290	0.0650	1.0000	240.0
Maneb	0.0110	0.0250	1.0000	240.0
Diazinon	0.0093	0.0210	0.2600	360.0
Carbaryl	0.0003	0.0007	0.3300	240.0
Fenvalerate	0.0003	0.0007	0.0420	140.0
Chlorpyrifos	0.0050	0.0110	0.4200	240.0
Dimethoate	0.0009	0.0019	0.2100	240.0
Metalaxyl	0.0082	0.0180	0.9200	120.0
Maximum Schedule				
Atrazine	0.0560	0.1300	0.8300	240.0
Oxyfluorfen	0.0750	0.1700	0.9200	120.0
Simazine	0.0120	0.0270	0.8300	240.0
Dicamba	0.0200	0.0450	0.2100	240.0
Glyphosate	0.0680	0.1500	0.8300	180.0
2,4-D	0.0230	0.0520	0.3000	140.0
Napropamide	0.0390	0.0870	0.6300	120.0
DCPA	0.0570	0.1300	4.4000	360.0
Bifenox	0.0410	0.0910	1.3000	120.0
Sethoxydim	0.0140	0.0300	0.1700	92.0
Diphenamid	0.0570	0.1300	4.4000	0.0
DCNA	0.0120	0.0270	0.4200	0.0
Triadimefon	0.0100	0.0220	0.2100	0.0
Chlorothalonil	0.0510	0.1100	0.6300	360.0
Benomyl	0.2200	0.4900	2.7000	0.0
Captan	1.0000	2.3000	13.0000	240.0
Maneb	0.0120	0.0260	1.0000	240.0
Diazinon	0.1500	0.3200	1.8000	360.0
Carbaryl	0.0003	0.0007	0.3300	240.0
Fenvalerate	0.0012	0.0027	0.0420	140.0
Chlorpyrifos	0.0120	0.0270	0.4200	240.0
Dimethoate	0.0009	0.0019	0.2100	240.0
Metalaxyl	0.0480	0.1100	3.3000	120.0

Table 3-18--Doses to weeders, inventory personnel, and lifters, sorters, packers, and tree planters for average and extreme reentry times, based on the generic application schedule (mg/kg)

Pesticide	Premature Reentry	Weeder Avg	Weeder Extr	Inventory Avg	Inventory Extr	Lifting Avg	Lifting Extr
			Mean Schedule				
Atrazine	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Oxyfluorfen	0.1100	0.0041	0.0570	0.0005	0.0940	0.0000	0.0000
Simazine	0.3400	0.0230	0.2000	0.0000	0.0000	0.0000	0.0000
Dicamba	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Glyphosate	0.1400	0.0067	0.0730	0.0270	0.0560	0.0001	0.0007
2,4-D	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Napropamide	0.1600	0.0007	0.0490	0.0039	0.0490	0.0000	0.0000
DCPA	1.5000	0.1600	0.9700	0.1100	0.9700	0.0005	0.0007
Bifenox	0.4600	0.0066	0.1800	0.0150	0.3500	0.0000	0.0000
Sethoxydim	0.0660	0.0000	0.0020	0.0000	0.0055	0.0000	0.0000
Diphenamid	0.9200	0.0150	0.3800	0.0013	0.3800	0.0000	0.0000
DCNA	0.1700	0.0240	0.1100	0.0240	0.1100	0.0000	0.0000
Triadimefon	0.0860	0.0430	0.0770	0.0130	0.0270	0.0001	0.0002
Chlorothalonil	0.1900	0.0900	0.1700	0.0340	0.1200	0.0038	0.0890
Benomyl	0.0750	0.0360	0.0660	0.0089	0.0660	0.0002	0.0054
Captan	0.4200	0.1600	0.3500	0.0430	0.2200	0.0000	0.0001
Maneb	0.4100	0.1600	0.3400	0.0000	0.0000	0.0110	0.0760
Diazinon	0.1100	0.0230	0.0760	0.0001	0.0029	0.0000	0.0000
Carbaryl	0.1400	0.0380	0.1000	0.0014	0.0160	0.0000	0.0000
Fenvalerate	0.0160	0.0002	0.0054	0.0002	0.0003	0.0000	0.0000
Chlorpyrifos	0.1700	0.0190	0.1000	0.0028	0.0250	0.0000	0.0000
Dimethoate	0.0850	0.0200	0.0620	0.0063	0.0270	0.0000	0.0000
Metalaxyl	0.3700	0.1100	0.2900	0.0150	0.2900	0.0000	0.0001
			Maximum Schedule				
Atrazine	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Oxyfluorfen	0.3800	0.0130	0.1900	0.0018	0.3100	0.0000	0.0000
Simazine	0.3400	0.0230	0.2000	0.0000	0.0000	0.0000	0.0000
Dicamba	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Glyphosate	0.3400	0.0170	0.1800	0.0650	0.1400	0.0002	0.0018
2,4-D	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Napropamide	0.2500	0.0011	0.0770	0.0061	0.0770	0.0000	0.0000
DCPA	1.8000	0.1800	1.1000	0.1300	1.1000	0.0006	0.0008
Bifenox	0.5100	0.0074	0.2000	0.0160	0.4000	0.0000	0.0000
Sethoxydim	0.0660	0.0000	0.0020	0.0000	0.0055	0.0000	0.0000
Diphenamid	1.8000	0.0290	0.7300	0.0025	0.7300	0.0000	0.0000
DCNA	0.1700	0.0240	0.1100	0.0240	0.1100	0.0000	0.0000
Triadimefon	0.0860	0.0430	0.0770	0.0130	0.0270	0.0001	0.0002
Chlorothalonil	0.2600	0.1200	0.2300	0.0460	0.1600	0.0052	0.1200
Benomyl	1.1000	0.5400	0.9800	0.1300	0.9800	0.0037	0.0800
Captan	5.1000	2.0000	4.3000	0.5200	2.6000	0.0001	0.0012
Maneb	0.4100	0.1600	0.3400	0.0000	0.0000	0.0110	0.0760
Diazinon	0.7200	0.1500	0.5100	0.0004	0.0200	0.0000	0.0000
Carbaryl	0.1400	0.0380	0.1000	0.0014	0.0160	0.0000	0.0000
Fenvalerate	0.0160	0.0002	0.0054	0.0002	0.0003	0.0000	0.0000
Chlorpyrifos	0.1700	0.0190	0.1000	0.0028	0.0250	0.0000	0.0000
Dimethoate	0.0850	0.0200	0.0620	0.0063	0.0270	0.0000	0.0000
Metalaxyl	1.4000	0.3800	1.0000	0.0540	1.0000	0.0000	0.0004

tables 3-9 and 3-10. The doses for premature reentry (2 hours after treatment) to a treated bed are also given. Doses from reentry exposure are calculated assuming pesticide degradation occurs from the day of application to the day of reentry; further degradation is not estimated for the period of time a worker is in a treated bed.

Fumigators

Fumigant exposure concentrations for routine situations are given in table 3-19. The results of the plume-model simulation of various accident conditions are given in table 3-20.

Tarp Lifters

The estimated exposure to methyl bromide for tarp lifters is included in table 3-19.

Seed Treaters

Routine exposures to seed treaters were estimated to be negligible. Accidental exposures were estimated to be 0.028 mg/kg for a 70-kg person working an 8-hour day.

Tree Planters

Accidental. Exposures were estimated for tree planters who handle benomyl-coated stock with bare hands. The doses are less than 0.08 mg/kg/day.

Doses to the Public

Dietary

Dietary doses to the public from eating beef, rabbit, grouse, and vegetables are listed in table 3-21. The doses from drinking water receiving runoff or drift are also listed in table 3-21.

Dermal

The doses from drift at 25 and 100 feet are presented in table 3-21. The dermal doses from petting a dog are also in table 3-21.

Inhalation

Concentrations of methyl bromide and chloropicrin at 25 feet downwind were estimated to be 0.320 ppm and 0.052 ppm, respectively. Exposures to 1,3-dichloropropene at 100 feet are estimated to be 0.053 ppm. Because total Vorlex concentrations would probably be similar to those for 1,3-dichloropropene, the concentration of the 1,3-dichloropropene component (approximately 40 percent) would be 0.02 ppm in Vorlex application.

Accidental exposures to the public are the same as those given for workers at 25 feet and 100 feet in table 3-20.

Table 3-19--Routine fumigant exposures (ppm) to workers

Chemical	Mean of studies	Standard deviation	Range[d]	Routine-realistic
Methyl bromide[a,b,c]				
Driver	3.33	2.08	0.42-7.68	1.73
Copilot	4.34	3.16	ND-10.82	2.26
Shoveler	1.03	1.02	ND-3.56	0.54
Tarp lifter[e]	--	--	--	14.7
Chloropicrin[b,c]				
Driver	556.3	875.1	51.6-2,593.9	0.289
Copilot	322.6	332.3	ND-1,021.44	0.168
Vorlex[f]	--	--	--	0.0015
1,3-Dichloropropene[g]	0.71	0.76	0.07-3.61	0.0037
Dazomet components				
MITC				0.372
Formaldelhyde				0.284
Monomethylamine				0.142
Hydrogen Sulfide				0.371

[a]Maddy et al. (1982).
[b]Maddy et al. (1983a).
[c]Maddy et al. (1984a).
[d]ND = not detectable.
[e]Van Den Oever (1982).
[f]Based on dichloropropene component.
[g]Maddy et al. (1984b).

Table 3-20--Accidental exposure concentrations (ppm) to fumigators[a]

Chemical	Distance to worker		
	5 feet	25 feet	100 feet
Methyl bromide (98% of 350 lb/acre)	88	86	65
Chloropicrin (33% of 350 lb/acre)	0.49	0.48	0.36
1,3-Dichloropropene (234 lb/acre)	0.75	0.73	0.55
Vorlex[b] (384 lb/acre)			
Total	0.50	0.50	0.38
1,3-Dichloropropene	0.20	0.20	0.15
MITC	0.10	0.10	0.08

[a]Based on the Gaussian plume model at a wind speed of 5 mph and slightly unstable atmospheric conditons.
[b]40% 1,3-dichloropropene, 20% MITC.

Table 3-21--Doses to the public from dietary and dermal exposures, based on the generic application schedule (mg/kg)

	Dietary									Dermal
Pesticide	Beef	Rabbit	Grouse	Vegs. 25 ft	Vegs. 100 ft	Water Runoff	Water Drift	25 ft	100 ft	Petting Dog
					Mean Schedule					
Atrazine	0.0002	0.0034	0.0028	0.009	0.006	0.0002	0.0000	0.0029	0.0018	0.0002
Oxyfluorfen	0.0001	0.0012	0.0009	0.003	0.002	0.0001	0.0000	0.0010	0.0006	0.0001
Simazine	0.0002	0.0034	0.0028	0.009	0.006	0.0003	0.0000	0.0029	0.0018	0.0002
Dicamba	0.0000	0.0009	0.0007	0.002	0.002	0.0002	0.0000	0.0007	0.0005	0.0000
Glyphosate	0.0001	0.0014	0.0011	0.004	0.003	0.0001	0.0000	0.0012	0.0008	0.0001
2,4-D	0.0001	0.0019	0.0015	0.006	0.004	0.0003	0.0000	0.0010	0.0007	0.0001
Napropamide	0.0001	0.0016	0.0013	0.004	0.003	0.0003	0.0000	0.0014	0.0009	0.0001
DCPA	0.0008	0.0150	0.0130	0.042	0.029	0.0005	0.0001	0.0130	0.0082	0.0008
Bifenox	0.0002	0.0046	0.0038	0.013	0.009	0.0004	0.0000	0.0039	0.0025	0.0002
Sethoxydim	0.0000	0.0007	0.0006	0.002	0.001	0.0001	0.0000	0.0006	0.0004	0.0000
Diphenamid	0.0004	0.0092	0.0075	0.025	0.017	0.0005	0.0001	0.0078	0.0050	0.0005
DCNA	0.0001	0.0017	0.0014	0.005	0.003	0.0001	0.0000	0.0014	0.0009	0.0001
Triadimefon	0.0000	0.0009	0.0007	0.002	0.002	0.0000	0.0000	0.0007	0.0005	0.0000
Chlorothalonil	0.0001	0.0019	0.0015	0.005	0.003	0.0001	0.0000	0.0016	0.0010	0.0001
Benomyl	0.0000	0.0008	0.0006	0.002	0.001	0.0001	0.0000	0.0006	0.0004	0.0000
Captan	0.0002	0.0042	0.0035	0.012	0.008	0.0004	0.0000	0.0036	0.0023	0.0002
Maneb	0.0002	0.0041	0.0034	0.011	0.008	0.0004	0.0000	0.0035	0.0022	0.0002
Diazinon	0.0000	0.0011	0.0009	0.003	0.002	0.0001	0.0000	0.0009	0.0006	0.0001
Carbaryl	0.0001	0.0014	0.0011	0.004	0.003	0.0001	0.0000	0.0012	0.0007	0.0001
Fenvalerate	0.0000	0.0002	0.0001	0.000	0.000	0.0000	0.0000	0.0001	0.0001	0.0000
Chlorpyrifos	0.0000	0.0017	0.0014	0.005	0.003	0.0001	0.0000	0.0014	0.0009	0.0001
Dimethoate	0.0000	0.0009	0.0007	0.002	0.002	0.0001	0.0000	0.0007	0.0005	0.0000
Metalaxyl	0.0001	0.0038	0.0031	0.010	0.007	0.0004	0.0000	0.0032	0.0020	0.0002
					Maximum Schedule					
Atrazine	0.0002	0.0034	0.0028	0.009	0.006	0.0002	0.0000	0.0029	0.0018	0.0002
Oxyfluorfen	0.0002	0.0038	0.0031	0.010	0.007	0.0002	0.0000	0.0032	0.0020	0.0002
Simazine	0.0002	0.0034	0.0028	0.009	0.006	0.0003	0.0000	0.0029	0.0018	0.0002
Dicamba	0.0000	0.0009	0.0007	0.002	0.002	0.0002	0.0000	0.0007	0.0005	0.0000
Glyphosate	0.0002	0.0034	0.0028	0.009	0.006	0.0001	0.0000	0.0029	0.0018	0.0002
2,4-D	0.0001	0.0019	0.0015	0.006	0.004	0.0003	0.0000	0.0010	0.0007	0.0001
Napropamide	0.0001	0.0026	0.0021	0.007	0.005	0.0004	0.0000	0.0022	0.0014	0.0001
DCPA	0.0009	0.0180	0.0150	0.049	0.034	0.0006	0.0001	0.0150	0.0097	0.0010
Bifenox	0.0002	0.0052	0.0042	0.014	0.010	0.0004	0.0000	0.0043	0.0028	0.0003
Sethoxydim	0.0000	0.0007	0.0006	0.002	0.000	0.0001	0.0000	0.0006	0.0004	0.0000
Diphenamid	0.0008	0.0180	0.0150	0.049	0.034	0.0010	0.0001	0.0150	0.0097	0.0010
DCNA	0.0001	0.0017	0.0014	0.005	0.003	0.0001	0.0000	0.0014	0.0009	0.0001
Triadimefon	0.0000	0.0009	0.0007	0.002	0.002	0.0000	0.0000	0.0007	0.0005	0.0000
Chlorothalonil	0.0001	0.0026	0.0021	0.007	0.005	0.0001	0.0000	0.0022	0.0014	0.0001
Benomyl	0.0006	0.0110	0.0091	0.030	0.021	0.0009	0.0000	0.0094	0.0060	0.0006
Captan	0.0024	0.0520	0.0420	0.140	0.097	0.0048	0.0000	0.0430	0.0280	0.0028
Maneb	0.0002	0.0041	0.0034	0.011	0.008	0.0004	0.0000	0.0035	0.0022	0.0002
Diazinon	0.0003	0.0073	0.0060	0.020	0.014	0.0004	0.0000	0.0062	0.0039	0.0004
Carbaryl	0.0001	0.0014	0.0011	0.004	0.003	0.0001	0.0000	0.0012	0.0007	0.0001
Fenvalerate	0.0000	0.0002	0.0001	0.000	0.000	0.0000	0.0000	0.0001	0.0001	0.0000
Chlorpyrifos	0.0000	0.0017	0.0014	0.005	0.003	0.0001	0.0000	0.0014	0.0009	0.0001
Dimethoate	0.0000	0.0009	0.0007	0.002	0.002	0.0001	0.0000	0.0007	0.0005	0.0000
Metalaxyl	0.0006	0.0140	0.0110	0.037	0.026	0.0015	0.0000	0.0120	0.0074	0.0008

Chapter 4
Risk Analysis

This chapter analyzes the risks to the health of workers and members of the public from the use of 28 pesticides, including herbicides, fungicides, insecticides, and fumigants, in Forest Service nurseries by comparing the exposure levels estimated in chapter 3 with the laboratory-determined toxicity reference levels described in chapter 2.

The first section of this chapter describes the methods used to evaluate those risks. The second section evaluates the risks of effects that occur only if a given dose level is reached. These threshold effects include acute toxic effects, chronic systemic effects, and effects on reproduction (maternal and fetal toxicity and birth defects). The last section evaluates the risks of nonthreshold effects: cancer or genetic mutations. For the analysis of cancer risk, lifetime doses computed in the exposure analysis are used with estimates of cancer potency determined in the hazard analysis to determine risk levels. Mutagenic risk is discussed on a qualitative basis. The possibility of synergistic effects, effects on sensitive individuals, and cumulative effects and are also discussed here.

Because the exposure situations are different (the principal route of exposure for the fumigants is via inhalation rather than dermal or dietary, as is the case with the other pesticides), the risks from fumigant exposure are discussed separately. All judgments about risk are discussed in light of the likelihood of the estimated exposures actually occurring.

HOW THE RISKS TO WORKERS AND THE PUBLIC WERE DETERMINED

In this risk analysis, the risks to humans exposed to the 28 nursery pesticides were quantified by comparing the representative doses estimated in the range of exposure situations presented in chapter 3 with the results of toxicity tests on laboratory animals described in chapter 2. To quantify the risks of threshold effects, the doses estimated for exposed individuals are compared to laboratory no-observed-effect levels (NOEL's) determined in the most sensitive animal test species. The ratio between the animal NOEL and the estimated human dose, referred to in this analysis as the margin of safety (MOS), is used to account for the uncertainty inherent in relating doses and effects seen in animals to estimated doses and effects that might be experienced by humans. For example, an MOS of 100 means that the laboratory-determined no-effect level is 100 times the estimated dose; an MOS of 10 means the laboratory-determined no-effect level is 10 times the estimated dose.

The larger the margin of safety (the smaller the estimated human dose compared to the animal NOEL), the lower the risk to human health. As the estimated dose to humans approaches the animal NOEL, the risk to humans increases. When an estimated dose exceeds a NOEL (giving an MOS of less than one), the ratio is reversed (the dose is divided by the NOEL) to indicate how high the estimated dose is above the laboratory no-effect level and a minus sign is attached to indicate that the estimated dose

exceeds the NOEL. A MOS of -3, for example, means that the estimated dose is 3 times the laboratory-determined no-effect level.

It can be inferred from a negative MOS that the estimated dose (given all the assumptions of the exposure situation) indicates some possibility of toxic effects, although it must be remembered that the MOS is based on a laboratory dose level that produced no toxic effects in test animals. When repeated doses to humans are much higher than the animal NOEL, there is a clear risk of harmful effects. Conversely, when the human dose is small compared with the animal NOEL (for example, giving an MOS greater than 100), the risk to humans can be judged negligible. EPA has typically used a safety factor of 100 to determine acceptable daily intakes for humans, based on chronic animal feeding studies; but a factor of 10 has been used for cholinesterase inhibitors (Conn et al. 1983)

All of the NOEL's used in this risk analysis are based on (or take into account) long-term exposure. A dose estimate that exceeds the laboratory test animal NOEL does not necessarily lead to the conclusion that there will be toxic effects. As an estimated dose approaches or exceeds an animal NOEL, the risk of toxic effects greatly increases, but comparing one-time or once-a-year doses (such as those experienced by the public or in an accident) to NOEL's derived from lifetime studies tends to exaggerate the risk from those rare events.

Estimated doses that exceed the NOEL are also compared to the pesticide's acute oral LD_{50}, so that a judgment can be made on the risk of fatalities. For convenience in this analysis, the ratio between the pesticide's LD_{50} and the estimated human dose also is expressed as an MOS; however, it should not be interpreted in the same way as the MOS based on a NOEL in terms of the expectation of no effects in humans.

Systemic effects are evaluated based on the lowest systemic NOEL found in a 2-year feeding study of dogs, rats, or mice, where possible. (When subchronic studies reported effects at lower levels than chronic studies, the subchronic NOEL's were used.) Reproductive effects, including the risk of birth defects, are evaluated based on the lowest maternal, fetotoxic, or teratogenic NOEL's found in a three-generation reproduction study or in a teratology study.

An analysis of cancer risk is conducted for the pesticides for which there are positive cancer studies. The risk of cancer is calculated for an individual by comparing estimates of lifetime dose (computed in chapter 3), averaged over a 70-year period, with cancer potency estimates derived in chapter 2. An analysis for the extreme case is also conducted for those pesticides that have positive mutagenicity tests or those for which no data are available. The risk of these herbicides causing mutations is qualitative rather than quantitative, with a statement of the probable risk based on the available evidence of mutagenicity and carcinogenicity.

RISK OF GENERAL SYSTEMIC AND REPRODUCTIVE EFFECTS

For each pesticide, for each application and nursery task, margins of safety were computed for routine-realistic, routine-extreme, and accident

situations for workers. For the public, margins of safety were computed for routine-realistic and routine-extreme situations. The only accidents assumed to affect the public are exposures to fumigants. The margins of safety were computed by comparing the laboratory-determined NOEL's and LD_{50}'s in table 4-1 with the doses shown in chapter 3. Table 4-2 lists toxic effects observed at the lowest effect levels in the same studies used to derive the systemic and reproductive NOEL's listed in table 4-1. Table 4-2 should be referred to when considering the likely toxic effects for those chemicals whose estimated exposure levels approach or exceed the NOEL.

Risk to the Public from Routine Operations Using Herbicides, Fungicides, and Insecticides

Margins of safety based on systemic and reproductive NOEL's for members of the public are greater than 100 in all exposure situations for all the nursery herbicides, all the fungicides, and for the insecticides carbaryl and fenvalerate. MOS's based on the LD_{50} are greater than 1,000 for the public for all the nursery herbicides, fungicides, and insecticides. This means the risk of human health effects from the use of all herbicides and fungicides in nurseries is negligible. A member of the public could be exposed every day under the routine conditions of herbicide and fungicide application and still not suffer any ill effects from that exposure.

Margins of safety for chlorpyrifos and diazinon are listed in table 4-3 for routine-realistic exposures to the public. The lowest chlorpyrifos and diazinon MOS's are for eating garden vegetables 100 feet offsite, eating a rabbit or grouse that has been exposed to chlorpyrifos or diazinon in a treated nursery bed, or being directly exposed to spray drift. The only MOS's in table 4-3 that are less than or equal to 10 are for eating vegetables. At a margin of safety of 10 for chlorpyrifos and diazinon, the exposure is equal to the acceptable daily intake determined by EPA. The lowest MOS of 9.4 for chlorpyrifos corresponds to a dose that is only 6 percent greater than the acceptable daily intake.

Chlorpyrifos and diazinon exposures with MOS's of less than 10 will not necessarily lead to toxic effects in exposed individuals. This is because the effect on which the systemic NOEL's of chlorpyrifos and diazinon are based is acetylcholinesterase (AChE) inhibition (see the discussion of chlorpyrifos toxicity in chapter 2). Acetylcholinesterase normally varies in humans by about 10 to 15 percent over a normal day. Because no effects were seen in animals at the NOEL, no significant acetylcholinesterase inhibition was produced. Only in extremely sensitive individuals are there likely to be any effects at all at doses below the animal NOEL. Some acetylcholinesterase inhibition would occur if the animal NOEL were exceeded (MOS negative) with the resulting effects likely to be only minor (for example, dryness of mouth), even with acetylcholinesterase inhibition up to 50 to 60 percent. Above 70 percent inhibition, more severe effects, such as dizziness, nausea, or blurred vision, may result. Above 80 percent inhibition there is a real danger of death (Thomas 1986). However, the dose would have to be very much higher than those estimated here to produce such inhibition levels.

Table 4-1--Toxicity reference values

Chemical	LD_{50} (mg/kg)	Systemic NOEL (mg/kg)	Reproductive NOEL (mg/kg)	Cancer potency
		Herbicides		
Atrazine	1,869.0	3.70	100.00	0.174000
Bifenox	6400.0	12.50	10.00	--
2,4-D	375.0	1.00	5.00	0.029200
DCPA	10,250.0	50.00	50.00	--
Dicamba	757.0	25.00	2.50	--
Diphenamid	1,373.0	3.00	10.00	--
Glyphosate	4,320.0	30.00	10.00	0.000024
Napropamide	5,000.0	25.00	10.00	--
Oxyfluorfen	5,000.0	0.30	0.50	0.000029
Sethoxydim	2,676.0	3.00	160.00	--
Simazine	5,000.0	5.00	5.00	--
		Fungicides		
Benomyl	10,000.0	12.50	5.00	0.006670
Captan	9,000.0	25.00	12.50	0.005440
Chlorothalonil	10,000.0	1.50	5.00	0.024000
DCNA	10,000.0	2.50	5.00	--
Maneb	4,500.0	2.00	5.00	0.556000
Metalaxyl	669.0	6.25	50.00	--
Thiram	560.0	1.90	2.40	--
Triadimefon	363.0	2.50	2.50	--
		Insecticides		
Carbaryl	270.0	10.00	3.13	0.135000
Chlorpyrifos	137.0	0.03	0.10	--
Diazinon	250.0	0.02	0.20	--
Dimethoate	250.0	0.20	7.50	0.0673
Fenvalerate	1,000.0	1.50	12.50	--

Table 4-2--Effects seen at lowest effect levels for nursery herbicides, fungicides, and insecticides

Pesticide	Systemic effects	Reproductive effects
	Herbicide	
Atrazine	Reduced food intake, decreased body weight, reduced hemoglobin and hematocrit values.	Fetal resorptions and fetal weight loss; maternal weight loss.
Bifenox	Studies available for review show no systemic or reproductive effects at the highest dose tested.	
2,4-D	Depressed growth, excessive mortality, increased liver weight, adverse effects in renal tubules and renal cortex.	Maternal weight loss; delayed ossification of fetuses.
DCPA	Loss in body weight, increased liver weight, centrilobular congestion in liver accompanied by degeneration.	Weak, blush pups; high mortality rate.
Dicamba	Slight liver cell alterations.	Increased fetal resorptions; increased postimplantation loss, reduced fetal body weights; maternal body weight reduction, mortality.
Diphenamid	Increased liver/body weight ratio, inflammatory hepatic cell infiltrates, vomiting, coughing.	Fetal liver congestion, hepatic cell glycogen depletion, irregular hepatic cell size.
Glyphosate	Toxic effects in kidneys, decreased blood glucose levels.	Renal focal tubular dilation of fetuses; diarrhea, nasal discharge, soft stools, mortality in dams.
Napropamide	Decreased uterine weights.	Decreased weight gain of fetuses and dams; increased incidence of incompletely ossified centra.

Table 4-2--Effects seen at lowest effect levels for nursery herbicides, fungicides, and insecticides (continued)

Pesticide	Systemic Effects	Reproductive Effects
Oxyfluorfen	Increased liver weight, non-neoplastic lesions on liver.	Decreased maternal weight gain.
Sethoxydim	Kidney damage.	Maternal weight loss, mortality, abortions, reduced number of litters and viable fetuses.
Simazine	Stomach ulcers, hyperemia of small intestine at very high doses.	No effects at highest doses tested.
	Fungicide	
Benomyl	Cirrhosis, body weight depression.	Microphthalmia, increased fetal mortality, reduced fetal weight.
Captan	Decreased body weights, hepato-cellular hypertrophy, increased kidney, heart, brain, liver, thyroid, and parathyroid weights.	Decreased mean litter weights, reduced ossification, increased resorptions.
Chlorothalonil	Kidney damage, including tubular dilation, pigmentation, and epithelial vacuolation.	Postimplantation losses, abortions, increased resorptions.
DCNA	Liver tissue changes at high doses.	Body weight reductions, skeletal and visceral variations in pups; CNS depression in dams.
Maneb	Anorexia, weight loss, impaired food consumption.	Increased abortions, still-births, and resorptions; fertility reduction.
Metalaxyl	Increased alkaline, phosphatase, increased liver/brain weight ratio.	Maternal convulsions and ataxia; fetal sternebrae #5 and/or #6 unossified.
Thiram	Strong appetite supression, skin rashes, and reaction to alcohol seen in humans.	Decreased litter size; reduction in gestational weight gain; fused ribs, cleft palates.

Table 4-2--Effects seen at lowest effect levels for nursery herbicides, fungicides, and insecticides (continued)

Pesticide	Systemic Effects	Reproductive Effects
Triadimefon	Decreased food consumption, body weight gain, erythrocyte count, and hemoglobin levels; increased liver weight.	Depression of maternal weight gain; decreased fetal weight gain.
	Insecticide	
Carbaryl	Acetylcholinesterase (AChE) depression.	Lack of tail, agenesis of external genitalia, failure of pubis and ischium to develop, abdominal fissures and visceral agenesis.
Chlorpyrifos	AChE depression.	Decreased fetal length and increased skeletal variants.
Diazinon	AChE depression.	Not available.
Dimethoate	Depressed growth and food consumption; increased kidney and liver weight ratios; slow decrease in whole-blood cholinesterase activity.	Maternal tremors and hyperapnea; reduced fetal body weight.
Fenvalerate	Multifocal granulomata in mesenteric lymph nodes, other lymph nodes, liver, and spleen.	Studies available for review show no reproductive effects at the highest dose tested.

Table 4-3--Margins of safety for chlorpyrifos and diazinon for the public in the routine-realistic situations[a]

	Chlorpyrifos		Diazinon	
	Based on systemic NOEL	Based on reproductive NOEL	Based on systemic NOEL	Based on reproductive NOEL
Eating beef	610	++	510	++
Eating rabbit	18	59	18	180
Eating grouse	21	71	23	230
Eating vegetables	9.4	31	10	100
Water, runoff	470	++	330	++
Water, drift	++	++	++	++
Dermal	33	110	34	340
Petting dog	320	++	340	++

[a]++ = greater than 1,000.

Risk to the Public from Routine-Extreme Case Exposures

Margins of safety for public exposure in routine-extreme case situations are greater than 100 except for captan, chlorpyrifos, diazinon, dimethoate, diphenamid, and oxyfluorfen. Table 4-4 lists the MOS's for systemic and reproductive effects for chlorpyrifos, diazinon, and oxyfluorfen in the routine-extreme exposure situations. Because the diazinon exposure values for the public approach or slightly exceed the systemic NOEL, there is a possibility that acetylcholinesterase inhibition may occur; however, it is likely to be transitory in nature and end soon after the exposure ceases. The lowest MOS for oxyfluorfen in the routine-extreme cases is 30 for eating vegetables. There is some slight risk in this instance that systemic effects may occur, although the risk of severe effects like permanent organ damage or significant effects on reproduction is negligible at these dose levels. No severe effects are likely to occur in any exposure to the public.

The only MOS's less than 100 for captan, dimethoate, and diphenamid occur in the instances of the public eating vegetables with drift residues from 25 feet offsite. (The captan MOS is 89 for reproductive effects, the dimethoate MOS is 87 for systemic effects, and the diphenamid MOS is 61 for systemic effects.) There is a very slight risk of reproductive effects resulting from captan exposure because the MOS for reproductive toxicity is less than 100. In dimethoate or diphenamid exposures, it is remotely possible, though unlikely, that limited, reversible health effects would occur. However, because these NOEL's were determined in long-term animal studies and the estimated exposures are likely to occur only very rarely, if at all, the risk to the public may be considered negligible.

Table 4-4--Margins of safety for chlorpyrifos, diazinon, and oxyfluorfen for the public in the routine-extreme situations[a]

	Chlorpyrifos		Diazinon		Oxyfluorfen	
	Based on systemic NOEL	Based on reproductive NOEL	Based on systemic NOEL	Based on reproductive NOEL	Based on systemic NOEL	Based on reproductive NOEL
Eating beef	610	++	77	770	++	++
Eating rabbit	18	59	2.7	27	79	130
Eating grouse	21	71	3.3	33	97	160
Eating vegetables	6.4	21	-1.0	10.0	30	50
Water, runoff	470	++	49	490	++	++
Water, drift	++	++	++	++	++	++
Dermal	21	71	3.2	32	94	160
Petting dog	320	++	50	500	++	++

[a]++ = greater than 1,000.

Risk to Workers from Routine Operations

All categories of workers' MOS's based on the LD_{50} for all pesticides are greater than 1,000 in the routine-realistic situations. Margins of safety for all worker categories in routine-realistic exposure situations based on systemic NOEL's are listed in table 4-5. MOS's for sorters, packers, and tree planters should be about the same as those calculated for lifters in all the exposure situations. Note that MOS's for the herbicides bifenox, DCPA, dicamba, diphenamid, glyphosate, napropamide, sethoxydim, and simazine; the fungicides benomyl and DCNA; and the insecticide fenvalerate are all greater than or equal to 100 for all worker categories.

Applicator MOS's, based on systemic NOEL's, are less than 100 for atrazine, 2,4-D, oxyfluorfen, chlorpyrifos, and diazinon. Sensitive individual applicators may experience low-level toxic effects such as appetite loss (atrazine), reversible neuropathy (2,4-D), or acetylcholinesterase inhibition (chlorpyrifos and diazinon).

Weeder MOS's, based on the systemic NOEL's, are less than 100 for oxfluorfen, chlorothalonil, maneb, metalaxyl, triadimefon, chlorpyrifos, diazinon, and dimethoate. Sensitive individuals may experience very minor short-term kidney or liver effects, particularly in the case of chlorothalonil, loss of appetite in the case of maneb exposure, and minor, reversible acetylcholinesterase depression in the case of chlorpyrifos or dimethoate. The diazinon weeder dose exceeds the systemic NOEL. In this case, some acetylcholinesterase inhibition is liable to occur; however, it is not likely to produce severe effects. Inventory personnel are at some risk (based on MOS's of less than 100) when working in nursery beds treated with chlorpyrifos, dimethoate, and chlorothalonil. The MOS for lifters is greater than 100 for all pesticides in the routine-realistic situation. Lifters are not at risk from exposures to any of the herbicides, fungicides, or insecticides under routine conditions.

In only a few cases are workers at risk of reproductive effects, based on MOS's of less than 100 (table 4-6). Applicators and weeders are again at highest risk in terms of possible reproductive effects from the use of diazinon and chlorpyrifos. Weeders are also at risk of reproductive effects from working in maneb-treated nursery beds, as are inventory personnel in chlorpyrifos-treated beds. Risk of reproductive effects is not as high for weeders in nursery beds treated with triadimefon, captan, carbaryl, or chlorothalonil or for applicators using oxyfluorfen.

Risk to Workers from Routine-Extreme Exposures

Margins of safety based on systemic NOEL's for workers in routine-extreme exposure situations are listed in table 4-7; table 4-8 lists MOS's based on reproductive NOEL's for workers in routine-extreme exposure situations.

MOS's based on systemic effects for benomyl, dicamba, glyphosate, napropamide, and fenvalerate are greater than 100 for all worker categories. Applicator MOS's based on the systemic NOEL's are less than

Table 4-5--Margins of safety based on systemic NOEL's for workers in routine-realistic situations[a]

	Applicator	Weeder	Inventory personnel	Lifter
Herbicides				
Atrazine	66	--	--	--
Bifenox	++	++	860	++
2,4-D	43	--	--	--
DCPA	++	320	450	++
Dicamba	++	--	--	--
Diphenamid	310	200	++	++
Glyphosate	++	++	++	++
Napropamide	++	++	++	++
Oxyfluorfen	38	73	560	++
Sethoxydim	220	++	++	++
Simazine	410	220	++	++
Fungicides				
Benomyl	++	350	++	++
Captan	860	150	580	++
Chlorothalonil	390	17	44	390
DCNA	310	100	100	++
Maneb	180	12	xx	190
Metalaxyl	760	59	430	++
Triadimefon	660	58	190	++
Insecticides				
Carbaryl	++	270	++	++
Chlorpyrifos	6.0	1.6	11	++
Diazinon	2.1	-1.2	340	++
Dimethoate	230	9.9	32	++
Fenvalerate	++	++	++	++

[a]-- = used only on cover crops, ++ = MOS greater than 1,000, and xx = no exposure.

Table 4-6--Margins of safety based on reproductive NOEL's for workers in routine-realistic situations[a]

	Applicator	Weeder	Inventory personnel	Lifter
Herbicides				
Atrazine	++	--	--	--
Bifenox	880	++	690	++
2,4-D	210	--	--	--
DCPA	++	320	450	++
Dicamba	170	--	--	--
Diphenamid	1,000	680	++	++
Glyphosate	++	++	380	++
Napropamide	++	++	++	++
Oxyfluorfen	63	120	930	++
Sethoxydim	++	++	++	++
Simazine	410	220	++	++
Fungicides				
Benomyl	++	140	560	++
Captan	430	76	290	++
Chlorothalonil	++	56	150	++
DCNA	620	210	210	++
Maneb	440	31	xx	470
Metalaxyl	++	470	++	++
Triadimefon	660	58	190	++
Insecticides				
Carbaryl	++	83	++	++
Chlorpyrifos	20	5.2	35	++
Diazinon	21	8.7	++	++
Dimethoate	++	370	++	++
Fenvalerate	++	++	++	++

[a]++ = MOS greater than 1,000, -- = used only on cover crops, xx = no exposure.

Table 4-7--Margins of safety based on systemic NOEL's for workers in routine-extreme situations[a]

	Applicator	Weeder	Inventory personnel	Lifter
Herbicides				
Atrazine	30	--	--	--
Bifenox	140	61	32	++[b]
2,4-D	19	--	--	--
DCPA	400	44	44	++
Dicamba	560	--	--	--
Diphenamid	24	4.1	4.1	++
Glyphosate	200	170	220	++
Napropamide	290	320	320	++
Oxyfluorfen	1.8	1.6	-1.0	++
Sethoxydim	99	++	540	++
Simazine	190	26	++	++
Fungicides				
Benomyl	25	13	13	160
Captan	11	5.9	9.4	++
Chlorothalonil	13	6.6	9.2	12
DCNA	93	23	23	++
Maneb	78	5.8	xx[c]	26
Metalaxyl	58	6.0	6.0	++
Triadimefon	110	33	93	++
Insecticides				
Carbaryl	++	97	630	++
Chlorpyrifos	1.1	-3.3	1.2	++
Diazinon	-16.	-25	1.0	++
Dimethoate	58	6.0	6.0	++
Fenvalerate	560	280	++	++

[a]-- = Used only on cover crops, ++ = MOS greater than 1,000, xx = No exposure.

Table 4-8--Margins of safety based on reproductive NOEL's for workers in routine-extreme situations[a]

	Applicator	Weeder	Inventory personnel	Lifter
Herbicides				
Atrazine	800	--	--	--
Bifenox	110	49	25	++
2,4-D	96	--	--	--
DCPA	400	44	44	++
Dicamba	56	--	--	--
Diphenamid	80	14	14	++
Glyphosate	66	55	73	++
Napropamide	110	130	130	++
Oxyfluorfen	3.0	2.7	1.6	++
Sethoxydim	++	++	++	++
Simazine	190	26	++	++
Fungicides				
Benomyl	10	5.1	5.1	63
Captan	5.5	2.9	4.7	++
Chlorothalonil	44	22	31	41
DCNA	190	47	47	++
Maneb	190	15	xx	66
Metalaxyl	470	48	48	++
Triadimefon	110	33	93	++
Insecticides				
Carbaryl	++	30	200	++
Chlorpyrifos	3.7	1.0	3.9	++
Diazinon	-1.6	-2.5	10	++
Dimethoate	470	48	48	++
Fenvalerate	++	++	++	++

[a]-- = Used only on cover crops, ++ = MOS greater than 1,000, xx = no exposure.

100 for atrazine, oxyfluorfen, 2,4-D, dimethoate, sethoxydim, diphenamid, captan, chlorothalonil, DCNA, chlorpyrifos, metalaxyl, maneb, and diazinon. The MOS for diazinon is -16, indicating the estimated routine-extreme applicator exposure is 16 times the NOEL. There is a clear risk of acetylcholinesterase inhibition in this case. The chlorpyrifos applicator MOS is 1.1, indicating that the estimated dose almost equals the NOEL. Here, too, acetylcholinesterase inhibition may occur, but the risk is not as great as with diazinon.

Weeder MOS's are less than 100 for oxyfluorfen, simazine, DCPA, benomyl, bifenox, captan, diphenamid, DCNA, triadimefon, chlorothalonil, maneb, metalaxyl, dimethoate, and carbaryl. The weeder MOS for chlorpyrifos is -3.3 and for diazinon is -25, indicating the estimated exposures are 3.3 and 25 times the NOEL, respectively.

Inventory personnel MOS's are less than 100 for oxyfluorfen (-1.0), DCPA, benomyl, bifenox, diphenamid, DCNA, triadimefon, chlorothalonil, metalaxyl, chlorpyrifos (1.2), dimethoate, and diazinon (1.0). Cholinesterase inhibition is likely in the case of the insectide exposures. Systemic effects are likely in the case of oxyfluorfen and diphenamid exposures and are slightly less likely with the fungicides captan, chlorothalonil, metalaxyl, and DCNA.

All MOS's for lifters based on the systemic NOEL's in the routine-extreme exposure situations are greater than 100 except for chlorothalonil and maneb. Some low-level, reversible effects may be experienced in these instances.

Margins of safety for all workers based on the reproductive NOEL's are greater than 100 for all worker categories for napropamide, dimethoate, fenvalerate, and sethoxydim. Applicator MOS's based on the reproductive NOEL's are less than 100 for 2,4-D, glyphosate, oxyfluorfen, dicamba, diphenamid, benomyl, captan, and chlorothalonil. The applicator MOS for chlorpyrifos is 3.7 and for diazinon is -1.6. There is some risk of reproductive effects for oxyfluorfen, benomyl, captan, chlorpyrifos, and diazinon.

Weeder MOS's are less than 100 for oxyfluorfen, glyphosate, simazine, DCPA, bifenox, diphenamid, for all of the fungicides, and for all of the insecticides except fenvalerate. The weeder MOS for chlorpyrifos is 1.0 and for diazinon is -2.5.

Inventory personnel MOS's based on the reproductive NOEL's are less than 100 for glyphosate, oxyfluorfen, DCPA, bifenox, diphenamid, for all of the fungicides, and for chlorpyrifos, diazinon, and dimethoate. Lifter MOS's are all greater than 100 except for benomyl, chlorothalonil, and maneb.

The routine-extreme exposure situations present a more pronounced risk of the same kinds of low-level toxic effects discussed under the routine-realistic exposures for the majority of the herbicides, fungicides, and insecticides used in the generic nursery. However, these exposure levels are far less likely to be experienced by any individual nursery

worker than the routine-realistic exposure levels. The latter exposures are averages, typical of those that occur each time an individual applies a chemical or works in a treated nursery bed. Routine-extreme exposures are liable to occur only rarely. Thus, the extreme situations should not greatly influence the overall risk to the workers in terms of long-term impacts on their health when compared to the routine exposures. In addition, because both the routine-realistic and routine-extreme MOS's are based on doses that produced no effects in laboratory animals in long-term studies, these comparisons tend to exaggerate the risk from the estimated exposures.

Risk to Workers from Accidents

Margins of safety for workers as a result of premature reentry, accidental spraying, and accidental spills of concentrate on their skin are listed in table 4-9. Except for spills of concentrate on the skin, all MOS's based on the oral LD_{50}'s are greater than 100.

Spills

Margins of safety based on the oral LD_{50} approach 1.0 for concentrate spill accidents for dicamba (3.2), 2,4-D (2.7), metalaxyl (5.6), fenvalerate (7.1), and carbaryl (1.1). The dimethoate estimated spill dose equals the oral LD_{50}. The chlorpyrifos and diazinon doses exceed the oral LD_{50}. In cases of spills of these pesticides, severe health effects to workers are possible and measures such as washing the skin immediately should be followed to prevent such effects from occurring. According to Doull et al. (1980):

> Organophosphate insecticides such as diazinon . . . are potent cholinesterase enzyme inhibitors that act by interfering with the metabolism of acetylcholine, which results in accumulation of acetylcholine at neuroreceptor transmission sites. Exposure produces a broad spectrum of clinical effects indicative of massive overstimulation of the cholinergic system, including muscarinic effects (parasympathetic), nicotinic effects (sympathetic and motor), and CNS effects (Namba 1971). These effects present clinically as feelings of headache, weakness, dizziness, blurred vision . . .

Particularly in the case of accidental spills of concentrate of carbaryl, diazinon, chlorpyrifos, and dimethoate on worker's skin there is a clear danger of severe, even fatal effects because acetylcholinesterase inhibition may exceed 80 percent and the dose approaches the LD_{50}. Normal applicator safety practices include wearing protective clothing, particularly rubber gloves, to greatly reduce the risk from such spills. However, some pesticide may still come into contact with the skin on rare occasions. In these instances, washing the pesticide off immediately and observing the exposed individual will ensure that any effects that do occur can be treated. Should severe effects occur, treatment with atropine may be necessary.

Table 4-9--Margins of safety for workers from accidental exposures

Pesticide	Premature reentry			Direct spray accident			Concentrate spill accident		
	Oral LD_{50}	Systemic NOEL	Reproductive NOEL	Oral LD_{50}	Systemic NOEL	Reproductive NOEL	Oral LD_{50}	Systemic NOEL	Reproductive NOEL
Herbicides									
Atrazine	--[a]	--[a]	--[a]	++	4.5	120	7.8	-65	-2.4
Bifenox	++	27	22	++	9.6	7.7	53	-9.6	-12
2,4-D	--[a]	--[a]	--[a]	++	3.3	17	2.7	-140	-28
DCPA	++	33	33	++	11	11	28	-7.2	-7.2
Dicamba	--[a]	--[a]	--[a]	++	120	12	3.2	-9.6	-96
Diphenamid	++	3.3	11	310	-1.5	2.3	--[b]	--[b]	--[b]
Glyphosate	++	220	72	++	36	12	24	-6	-18
Napropamide	++	160	62	++	40	16	42	-4.8	-12
Oxyfluorfen	++	2.6	4.4	++	-3.1	-1.8	42	-400	-240
Sethoxydim	++	45	++	++	18	940	29	-31	1.7
Simazine	++	15	15	++	6.0	6.0	21	-48	-48
Fungicides									
Benomyl	++	170	67	++	4.6	1.9	--[b]	--[b]	--[b]
Captan	++	59	30	690	1.9	-1.0	38	-9.6	-19
Chlorothalonil	++	8.0	27	++	2.4	7.9	28	-240	-72
DCNA	++	15	30	++	6.0	12	--[b]	--[b]	--[b]
Maneb	++	4.9	12	++	2.0	5.0	19	-120	-48
Metalaxyl	++	17	130	200	1.9	15	5.6	-19	-2.4
Thiadimefon	++	29	29	++	12	12	--[b]	--[b]	--[b]
Insecticides									
Carbaryl	++	74	23	820	30	9.5	1.1	-24	-77
Chlorpyrifos	810	-5.6	-1.7	330	-14	-4.2	-1.8	-8,000	-2,400
Diazinon	++	-5.4	-1.9	140	-90	-9.0	-1.4	-18,000	-1,800
Dimethoate	++	2.4	88	++	-1.0	36	1.0	-1,200	-32
Fenvalerate	++	91	760	++	36	300	7.1	-93	-11

[a]Used only on cover crop, no reentry.
[b]Not prepared from liquid formulation.

For the pesticides other than insecticides, there is some possibility that the damage caused by such large acute doses could cause long-term damage to vital organs. There have also been rare instances in which limited exposure to 2,4-D caused permanent nerve damage. The dose and the risk are much greater for spills of concentrate than for the spray mix but, again, it is highly unlikely that a worker would allow the chemical to penetrate his skin for any length of time.

For concentrate spill accidents, all margins of safety based on systemic NOEL's and reproductive NOEL's are negative for those pesticides used in liquid formulations. Diphenamid, DCNA, and triadimefon are not used in liquid formulations, so only the spray mix is liable to be spilled.

Premature Reentry

For premature reentry, all MOS's based on the oral LD_{50}'s are greater than 1,000 except for chlorpyrifos, which is 810. MOS's based on the systemic NOEL are greater than 100 for napropamide, glyphosate, and benomyl. Workers other than applicators receive no atrazine, dicamba, 2,4-D, or captan exposures in reentry because these are used only on cover crops or for seed treatment. The MOS's for all other pesticides are below 100. The chlorpyrifos MOS is -5.6 and the diazinon MOS is -5.4 for systemic effects. Risk of systemic effects from premature reentry is greatest for these two insecticides.

Premature reentry MOS's based on the reproductive NOEL are greater than 100 for sethoxydim and fenvalerate. All other MOS's based on the reproductive NOEL for premature reentry are less than 100. Again, the chlorpyrifos and diazinon doses exceed the NOEL, so the risk of reproductive effects is greatest with these two insectides.

Spray Accidents

For direct accidental spraying of a worker, margins of safety based on the systemic NOEL's are less than 100 for all pesticides except dicamba. Those for oxyfluorfen, diphenamid, chlorpyrifos, dimethoate, and diazinon are negative (the estimated exposure exceeds the NOEL).

Margins of safety for spray accidents based on the reproductive NOEL are greater than 100 for atrazine, sethoxydim, and fenvalerate. All others are less than 100. Oxyfluorfen, captan, chlorpyrifos, and diazinon MOS's are negative.

It must be noted that the dose levels resulting from these spray accidents, as well as the spill accidents, are based on dermal penetration levels derived in studies over many days; these chemicals do not penetrate the skin immediately but over some period of time. Thus, workers would have to ignore their own safety and <u>not</u> wash the chemical off to receive doses as high as predicted from such accidents.

Risks from the Use of Fumigants

Health Effects of Fumigant Exposures

At low levels of exposure to the fumigants evaluated in this analysis, a number of minor, reversible health effects may be experienced. Methyl bromide and chloropicrin are both extremely irritative, volatile chemicals that cause tearing of the eyes, swelling of bronchial membranes, and a gasping response. Methyl bromide's effects are more delayed than chloropicrin's. Chloropicrin has an odor, whereas methyl bromide does not, which is why chloropicrin is used as a warning agent in the fumigant mixture of these two chemicals.

1,3-Dichloropropene is less immediately irritative than either methyl bromide or chloropicrin, but at the same exposure levels it is liable to produce more swelling of the mucous membranes. Vorlex, which contains 1,3-dichloropropene, will produce these same effects but at relatively higher exposure levels.

Such low-level effects are likely to be seen at exposure levels of 0.5 ppm. At higher levels of exposure (1 ppm and above), more severe irritation--with fluid filling the bronchial cells and the lungs--may occur, which can lead to eventual cell death when exposures are continued over several days. 1,3-Dichloropropene produces reversible liver cell changes. At higher levels and years of exposure, it may cause cancer. Workers who are exposed to fumigants on a daily or weekly basis may suffer these types of health effects.

In the case of very high levels (several hundred parts per million) of exposure to any of the fumigants, severe effects may occur that can lead to death in a relatively short period of time if the exposed person is not removed from the area. Methyl bromide (LC_{50} = 396 ppm) produces central nervous system depression that initially leads to dizziness, nausea, vomiting, blurred vision, and incoordination. Continued exposure at high levels leads to coma and death. High-level exposure also can lead to cardiac arrest. The lowest level found lethal in humans is 6,000 ppm over 2 hours. The chloropicrin in the mixture of methyl bromide and chloropicrin, although it is more acutely toxic (LC_{50} = 25.5 ppm) than any of the other fumigants, is so irritative that the immediate response of individuals exposed to high levels (several hundred ppm) is to remove themselves from the exposure source. Chloropicrin forms only a fraction of the fumigant mixture, so it is not likely that a fatally toxic dose will be received. 1,3-Dichloropropene (LC_{50} = 729 ppm) is less toxic than methyl bromide, so much higher levels would have to be experienced for these effects to occur. Vorlex (LC_{50} = 2,651 ppm) is the least toxic of the fumigant mixtures and is likely to result in severe effects only if used in a confined space--for example, a greenhouse--over a long exposure period.

The major breakdown products of dazomet include MITC (LC_{50} = 637 ppm), formaldehyde (LC_{50} = 75 ppm), hydrogen sulfide (LC_{50} = 444 ppm), and monomethylamine (LC_{50} = 1,893 ppm). Formaldehyde and hydrogen sulfide are dermal and respiratory tract irritants. Hydrogen sulfide is also irritating to the eyes.

Risk to the Public from Fumigant Exposure

This analysis assumes that there is some level of exposure to the public downwind from a fumigant operation even though normal practices with methyl bromide, Vorlex, and 1,3-dichloropropene include injection into the ground and, in the case of methyl bromide, immediate sealing with plastic. Dazomet is incorporated into the soil in granular form, then the treated area is irrigated. These practices should minimize release of MITC and formaldehyde, as well as reduce the public risk considerably, so that only accidents should pose any significant risk.

Accidental releases of dazomet are very unlikely because it is applied in granular form, so these exposures are not included in this analysis. Table 4-10 lists exposures to the public from the routine use of fumigants and from accidental releases of fumigants, with margins of safety based on inhalation toxicity levels. MOS's for the routine scenario are based on exposures from worker field studies or field dissipation studies (dazomet). The MOS's for the accidental spill of methyl bromide are based on a 98-percent methyl bromide/2-percent chloropicrin mixture. The chloropicrin MOS's are based on a 67-percent methyl bromide/33-percent chloropicrin mixture.

In no instances do any of the public exposure levels approach the levels that constitute the severe risk of toxic effects described above. However, all MOS's are lower than 100 so it is likely that individuals exposed in these situations will experience some low-level effects, such as tearing and bronchial irritation, should they be immediately downwind of a fumigation operation.

The accidental release scenarios assume that as a chemical plume moves downwind it maintains a fairly stable concentration, so that the public receives doses that are comparable to worker doses. In accidental releases of methyl bromide and chloropicrin, there is a greater risk of effects because the MOS's are negative. However, any effects are still likely to be only the low-level ones described above. These exposures are likely to be very short because of the extremely irritative properties of the chemicals.

Risk to Workers from Routine Fumigant Operations

Table 4-11 lists margins of safety for workers involved in routine fumigation procedures based on exposure levels found in worker field studies. The methyl bromide MOS's are based on a 98-percent methyl bromide/2-percent chloropicrin mixture. The chloropicrin MOS's are based on a 67-percent methyl bromide/33-percent chloropicrin mixture. No studies of chloropicrin exposure to tarp lifters or shovelers, were found in the literature, so these MOS's are not estimated. 1,3-dichloropropene, dazomet, and Vorlex operations do not use tarps, so the MOS's for these two chemicals are given for applicators only.

Workers applying 1,3-dichloropropene and Vorlex are at very low risk in routine operations because their MOS's are greater than 100. Workers exposed to the 98-percent methyl bromide/2-percent chloropicrin mixture

Table 4-10--Margins of safety for public exposure to fumigants

Fumigant	Exposure (ppm)	NOEL (ppm)	MOS based on the NOEL
Routine			
Methyl bromide (at 25 feet)	0.320[a]	16	50
Chloropicrin (at 25 feet)	0.052[a]	0.1[b]	1.9
1,3-Dichloropropene (at 100 feet)	0.053[c]	1	19
Vorlex	0.02	1	50
Dazomet components			
MITC	0.372	10	27
Formaldehyde	0.284	1[b]	3.5
Monomethylamine	0.142	10[b]	70
Hydrogen sulfide	0.371	10[b]	27
Accidental[d]			
Methyl bromide			
(at 25 feet)	86	16	-5.4
(at 100 feet)	65		-4.1
Chloropicrin			
(at 25 feet)	0.48	0.1[b]	-4.8
(at 100 feet)	0.36		-3.6
1,3-Dichloropropene			
(at 25 feet)	0.73	1	1.4
(at 100 feet)	0.55		1.8
Vorlex components[e]			
1,3-Dichloropropene			
(at 25 feet)	0.20	1	5.0
(at 100 feet)	0.15		6.7
MITC			
(at 25 feet)	0.10	10[f]	100
(at 100 feet)	0.08		125

[a]Maddy et al. 1983b.
[b]NOEL not available, value given is the TLV.
[c]Maddy et al. 1980.
[d]Based on plume model at 5 mph and slightly unstable conditions.
[e]Assumes Vorlex contains 40 percent 1,3-dichloropropene and 20 percent MITC.
[f]NOEL for MITC based on 12- to 13-week rat inhalation study (Schering 1983).

Table 4-11--Margins of safety for fumigant exposure to workers during routine operations

	Average exposure for workday (ppm)	NOEL (ppm)	MOS based on the NOEL
Methyl bromide		16	
Driver	1.73		9.2
Copilot	2.26		7.1
Shoveler	0.54		29.6
Tarp lifter	14.7		1.1
Chloropicrin[a]		0.1	
Driver	0.289		-2.9
Copilot	0.168		-1.7
1,3-Dichloropropene	0.0037	1	270
Vorlex[b]	0.0015	1	667
Dazomet components			
MITC	0.372	10	27
Formaldehyde	0.284	1	3.5
Monomethylamine	0.142	10	70
Hydrogen sulfide	0.371	10	27

[a]The NOEL was not known for chloropicrin, so it has been estimated as 0.1, which is the threshold limit value. This compares with the lowest toxic level reported (TC_{LO}) of 0.3 ppm.
[b]These calculations are for the 1,3-dichloropropene fraction, but Vorlex itself has been shown to have a similar NOEL because of the added toxicity of the MITC component.

from routine application or tarp lifting operations are at risk of low-level effects. Tarp lifters are at highest risk, with an MOS that approaches the NOEL for methyl bromide.

Workers applying the high percentage (33 percent) chloropicrin mixture are at highest risk in routine operations because their MOS's are negative. They are quite likely to experience the low-level effects of tearing, and bronchial irritation and swelling. Workers applying dazomet are at moderate risk based on their total exposures, but these risks should be mitigated by the lag time in generation of the toxic compounds in the soil.

Risk to Workers from Accidents Involving Fumigants

Table 4-12 lists the lowest margins of safety for workers exposed to a spill of fumigant. As in the routine operations, workers are at greatest risk of low-level effects from the use of one of the methyl bromide + chloropicrin mixtures. In the case of a spill, 1,3-dichloropropene exposures also approach the NOEL, so there is a much greater risk of toxic effects in this situation than in the routine uses of the chemical. The same is true of the use of Vorlex, although the lower percentage of 1,3-dichloropropene in this fumigant mixture leads to lower overall risk.

CANCER RISK

A risk analysis for cancer was conducted for 13 pesticides. These include atrazine, chlorothalonil, oxyfluorfen, benomyl, captan, dimethoate, 1,3-dichloropropene, and methyl bromide, which had positive laboratory oncogenicity studies; 2,4-D, glyphosate, and carbaryl (based on the suspicion that nitrosocarbaryl may form in the human stomach); maneb because its principal degradation product ethylene thiourea (ETU) has been shown to be oncogenic; and dazomet because its degradation product formaldehyde has been shown to be oncogenic.

Although no positive results have been observed in any thiram oncogenicity study, the preponderance of data indicating mutagenic responses in various test systems support the contention that thiram is a possible carcinogen. Because of a lack of tumor data, no quantitative assessment of thiram cancer risk could be made at this time. There is some question concerning the carcinogenicity of fenvalerate because it produced spindle cell sarcomas in one oncogenicity study. However, the preponderance of evidence from other cancer studies and the lack of positive mutagenicity results lead to the conclusion, at this time, that the human risk of cancer from fenvalerate use in nurseries is negligible. All of the other pesticides have negative cancer studies.

Risk of Cancer from the Pesticides

Cancer risks for 13 pesticides listed in the previous section have been calculated based on a number of conservative assumptions that are likely to exaggerate the risks. These assumptions include the following:

1. Even though carbaryl and 2,4-D have not been shown conclusively to be carcinogenic in laboratory tests, these pesticides are assumed to be carcinogenic.

2. In cases where there is more than one tumor data set available, the data set indicating greater carcinogenic potency has been chosen. The carcinogenic potency of 2,4-D, for example, has been calculated based on the rate of tumor formation in the female Osborne-Mendel rats studied by Hansen et al. (1971). This is the species and sex that have exhibited the highest rate of tumor formation after 2,4-D administration. All tumors were considered, although many of them were benign.

Table 4-12--Margins of safety for worker accidental exposure to fumigants[a]

	Exposure (ppm)	LC_{50} (ppm)	NOEL (ppm)	MOS based on the LC_{50}	MOS based on NOEL
Methyl bromide	88	396	16	4.5	-5.5
Chloropicrin	0.49	25.5	0.1	52	-4.9
1,3-Dichloropropene	0.75	729	1	972	1.3
Vorlex components[b]					
1,3-Dichloropropene	0.20	729	1	3,645	5.0
MITC	0.10	637	10	6,370	100

[a]Based on plume model at 5 feet, wind 5 mph, spill diameter 1 m.
[b]Assumes Vorlex contains 40 percent 1,3-dichloropropene and 20 percent MITC.

3. It is assumed that carcinogenicity is not a threshold phenomenon; that is, any dose of these chemicals has some probability of causing cancer, no matter how small the dose.

4. The one-hit model was used to represent the relationship between dose and rate of tumor formation. This is more conservative than several other models that have been proposed because it predicts higher cancer rates at the relatively low doses predicted for exposed humans. Other models that could have been used include the multistage, multihit, Weibull, logit, and probit models. The choice of model can affect the predicted cancer rates over several orders of magnitude. The one-hit model was used at one time by EPA, but the less conservative multistage model is now normally used.

5. In each case, a 95-percent upper confidence limit was used to estimate cancer potency. For 2,4-D, these potencies were estimated using the maximum-likelihood procedure of the GLOBAL 82 computer program (Howe and Crump 1982). The unit cancer risk of formaldehyde was determined by EPA (1986f). For the other chemicals, a least squares regression procedure was used.

6. Interspecies extrapolation from test animals to humans is a major source of uncertainty in judging cancer risk. The scaling method used in this analysis is the most conservative of the commonly accepted methods. The cancer potency of each chemical for humans was assumed to be the same as the potency for rats

when scaled in terms of body surface area. This method is recommended by EPA and others (Thomas 1986), but it is not the only acceptable approach. Another acceptable method (OSTP 1985) is to scale doses directly to body weight, resulting in estimates of cancer risk that are about 16 percent of those calculated here.

7. The range of doses calculated for workers and the public in the basic scenarios covers even extreme exposures that might be encountered with each application method. Unusual exposure situations, represented by accidental spraying and large herbicide spills, have also been considered.

The probability of occurrence of cancer over a lifetime as a result of exposure to each of the chemicals was calculated using the following equations:

$$P(d) = 1 - \exp(-K \times b \times d)$$
$$d = D \times N/L$$

where

P(d) = a conservative estimate of the probability of cancer during a person's lifetime as the result of dose d

d = the average daily dose over a lifetime (mg/kg/day)

b = a conservative estimate for cancer potency in the test animal

K = an interspecies extrapolation factor, used to correct b for application to humans

D = the daily dose (mg/kg/day)

N = the number of days during which the dose D occurs during an individual's lifetime

L = the number of days in a lifetime, taken to be 25,550 for a 70-year lifespan

The following cancer potencies (K x b, in per mg/kg/day) were used for humans: atrazine, 0.174; 2,4-D, 0.0292; glyphosate, 0.000024; oxyfluorfen, 0.000029; benomyl, 0.00667; captan, 0.00544; chlorothalonil, 0.024; maneb, 0.556; carbaryl, 0.135; dimethoate, 0.06730; methyl bromide, 0.169; 1,3-dichloropropene, 0.32. The unit cancer risk for formaldehyde was taken to be 1.3×10^{-5} per μ/m^3 of exposure over a 70-year lifetime.

The interspecies extrapolation factor, K, can be estimated by assuming that body surface area is proportional to body weight to the 2/3 power

(Mantel and Schneiderman 1975). Extrapolation to humans from animal doses expressed as mg/kg uses the following equation:

$$K = (\text{human weight/test animal weight})^{1/3}$$

For an average human weight of 70 kg and an average rat weight of 350 g, K is estimated to be 5.8. For mice weighing 25 g, K is 14.1. These values were used in the analysis although lesser values would apply if a smaller human weight were assumed.

Cancer Risk to the Public

Cancer risk from the pesticides, except fumigants, for the general public has been calculated for 5 exposures and for 30 exposures over a lifetime. Individual exposure routes were considered separately in estimating cumulative risk. The routes included eating a contaminated rabbit, eating garden vegetables grown 25 feet from the spray site, drinking water that has received spray drift, and direct exposure to drift 25 feet from the spray site. Table 4-13 indicates that only in a few of the 30-exposure situations--maneb exposures and atrazine on vegetables--is the risk of cancer greater than 1 in 1 million (1×10^{-6}). In no instance does the risk exceed 1 in 100,000 (1×10^{-5}).

Cancer risk to the public from fumigant exposure is shown in table 4-14. The risks have been calculated for 5 years and for 10 years assuming that exposures occur for a total of 24 hours per year. Risks for Vorlex were calculated based on the 1,3-dichloropropene component, and risks for dazomet were calculated based on the formaldehyde breakdown product. Risks from accidental exposure have been calculated assuming that a spill situation results in a 5-minute exposure and they do not exceed 1 in 1 million. However, multiple exposures under routine conditions may result in higher risks. After 10 years of exposure, cancer risk from methyl bromide fumigation may be 2 in 100,000, or 6 in 1 million from 1,3-dichloropropene. Dazomet risks are less than 1 in 1 million.

Cancer Risk to Workers

Cancer risk from the pesticides, except fumigants, to workers has been calculated for an expected case assuming 5 years of employment in the nurseries and for an extreme case assuming 30 years of employment. It is very unlikely that a worker would receive exposure greater than this. The lifetime cancer risks for workers are shown in table 4-15.

Cancer risks to workers exposed for 5 years do not exceed 8 in 100,000 except for weeders exposed to maneb, who could have a risk of 8 in 10,000. Cancer risk from longer exposures would be proportionately greater. After 30 years of exposure, the risk from maneb exposure would be a maximum of 5 in 1,000. The maximum risk from exposure to the other chemicals would be 8 in 100,000.

Cancer risks to workers from fumigants have been calculated assuming that workers are exposed for 38 hours per year, the average work time reported for fumigators (USDA 1986b). The risks are shown in table 4-16

Table 4-13--Lifetime cancer risk for exposed members of the public: generic nursery

Exposures	Atrazine	Oxyfluorfen	2,4-D	Chlorothal	Benomyl	Captan	Maneb	Carbaryl	Dimethoate
5 Exposures									
Rabbit	1×10^{-7}	6×10^{-12}	1×10^{-8}	8×10^{-9}	9×10^{-10}	3×10^{-9}	4×10^{-7}	3×10^{-8}	1×10^{-8}
Vegetation (25 ft)	3×10^{-7}	2×10^{-11}	3×10^{-8}	2×10^{-8}	3×10^{-9}	7×10^{-9}	1×10^{-6}	8×10^{-8}	3×10^{-8}
Water, drift	5×10^{-10}	5×10^{-14}	5×10^{-11}	1×10^{-10}	1×10^{-11}	9×10^{-12}	3×10^{-9}	1×10^{-9}	1×10^{-10}
Dermal (25 ft)	1×10^{-7}	5×10^{-12}	6×10^{-9}	6×10^{-9}	8×10^{-10}	2×10^{-9}	4×10^{-7}	--[a]	9×10^{-9}
30 Exposures									
Rabbit	7×10^{-7}	4×10^{-11}	7×10^{-8}	5×10^{-8}	6×10^{-9}	2×10^{-8}	3×10^{-6}	2×10^{-7}	7×10^{-8}
Vegetation (25 ft)	2×10^{-6}	1×10^{-10}	2×10^{-7}	1×10^{-7}	2×10^{-8}	4×10^{-9}	7×10^{-6}	5×10^{-7}	2×10^{-7}
Water, drift	3×10^{-9}	3×10^{-13}	3×10^{-10}	7×10^{-10}	6×10^{-11}	5×10^{-11}	2×10^{-8}	6×10^{-9}	6×10^{-10}
Dermal (25 ft)	6×10^{-7}	3×10^{-11}	3×10^{-8}	4×10^{-8}	5×10^{-9}	1×10^{-8}	2×10^{-6}	--[a]	6×10^{-8}

[a]Calculated only from nitrosocarbaryl formation in the stomach from oral doses.

Table 4-14--Cancer risk for the public exposed to fumigants

Exposure	Methyl Bromide	1,3-Dichloropropene	Vorlex[a]	Dazomet[b]
5 years of exposure	8×10^{-6}	3×10^{-6}	4×10^{-7}	5×10^{-7}
10 years of exposure	2×10^{-6}	6×10^{-6}	8×10^{-7}	9×10^{-7}
Accidental exposure	1×10^{-6}	3×10^{-8}	7×10^{-9}	NA[c]

[a]Risk is for the 1,3-dichloropropene component.
[b]Risk is for the formaldehyde breakdown product.
[c]Not applicable.

for 5 and 30 years of fumigation work during a 70-year lifetime. Risks are also shown in this table for accidental exposures, assuming that a major accident occurs only once (or that several smaller accidents occur). The accidental exposure was calculated by the Gaussian plume model assuming that a broken hose results in a 5-minute exposure without a respirator at 5 feet from the source. The cancer risk for Vorlex was calculated based on the 1,3-dichloropropene component. In all cases, it was assumed that 50 percent of inspired fumigant was absorbed and the respiration rate was 18 liters per minute.

Comparison of Cancer Risks with Other Common Risks

To put the cancer risks calculated here in perspective, table 4-17 lists risks associated with some more familiar hazards and occupational risks. A variety of hazards are listed in the table that have a risk of about 1 in 1 million. They include smoking 2 cigarettes, eating 6 pounds of peanut butter, drinking 40 sodas sweetened with saccharin, or taking one transcontinental round trip by air. The cancer risk for a single x-ray is 7 in 1 million. Many occupational risks are greater. Working for 30 years in agriculture or construction has a risk of about 2 in 100; and in mining and quarrying the risk is even greater--3 in 100 over 30 years.

RISK OF HERITABLE MUTATIONS

No human studies are available that associate any of the pesticides with heritable mutations. Furthermore, no risk assessments that quantify the probability of genetic mutations are available in the literature or from the Environmental Protection Agency. Laboratory studies constitute the best available information on mutagenic potential. Results of the mutagenicity assays conducted on the pesticides are summarized in table 2-5 in chapter 2.

Table 4-15--Lifetime cancer risk for workers: generic nursery

Exposure	Atrazine[a]	Oxyfluorfen	Glyphosate	2,4-D[a]	Chlorothalonil	Benomyl	Captan	Maneb	Dimethoate
5 Years									
Weeding	--	9×10^{-10}	8×10^{-10}	--	1×10^{-5}	1×10^{-6}	1×10^{-5}	8×10^{-4}	2×10^{-6}
Inventory	--	5×10^{-11}	1×10^{-9}	--	2×10^{-6}	1×10^{-7}	1×10^{-6}	--	3×10^{-7}
Lifting	--	5×10^{-13}	8×10^{-12}	--	4×10^{-7}	6×10^{-9}	2×10^{-10}	4×10^{-5}	1×10^{-14}
Application	2×10^{-6}	3×10^{-10}	6×10^{-11}	1×10^{-6}	3×10^{-7}	5×10^{-8}	4×10^{-8}	4×10^{-6}	5×10^{-9}
30 Years									
Weeding	--	6×10^{-9}	5×10^{-9}	--	8×10^{-5}	7×10^{-6}	6×10^{-5}	5×10^{-3}	1×10^{-5}
Inventory	--	3×10^{-10}	8×10^{-9}	--	1×10^{-5}	7×10^{-7}	7×10^{-6}	--	2×10^{-6}
Lifting	--	3×10^{-12}	5×10^{-11}	--	3×10^{-6}	4×10^{-8}	1×10^{-9}	2×10^{-4}	9×10^{-14}
Application	1×10^{-5}	2×10^{-9}	3×10^{-10}	7×10^{-6}	2×10^{-6}	3×10^{-7}	3×10^{-7}	2×10^{-5}	3×10^{-8}

[a]Used for cover crop only.

Table 4-16--Cancer risk for workers using fumigants

Exposure	Methyl Bromide	1,3-Dichloropropene	Vorlex[a]	Dazomet[b]
5 Years of exposure				
Driver	7×10^{-5}	3×10^{-7}	5×10^{-8}	7×10^{-7}
Copilot	8×10^{-5}	3×10^{-7}	5×10^{-8}	7×10^{-7}
Shoveler	2×10^{-5}	NA[c]	NA	NA
30 Years of exposure				
Driver	4×10^{-4}	2×10^{-6}	3×10^{-7}	4×10^{-6}
Copilot	5×10^{-4}	2×10^{-6}	3×10^{-7}	4×10^{-6}
Shoveler	1×10^{-4}	NA	NA	NA
Accidental exposure	1×10^{-6}	3×10^{-8}	7×10^{-9}	NA

[a]Risk is for the 1,3-dichloropropene component.
[b]Risk is for the formaldehyde breakdown product.
[c]Not applicable.

For some of the pesticides, no validated mutagenicity tests exist, or the mutagenicity tests conducted are insufficient to conclude whether the chemical is mutagenic. For these pesticides, a conservative assumption may be made that they have the potential to cause mutations in humans. In these cases, the results of carcinogenicity tests (table 2-5 in chapter 2) or cancer risk assessments can be used to estimate the risk of heritable mutations.

The rationale for this assumption is summarized by the U.S. Department of Agriculture (1985a) as follows:

> Since mutagenicity and carcinogenicity both follow similar mechanistic steps (at least those that involve genetic toxicity), the increased risk of cancer can be used to approximate the quantitative risk of heritable mutations. The basis for this assumption is that both mutagens and at least primary carcinogens react with DNA to form a mutation or DNA lesion affecting a particular gene or set of genes. The genetic lesions then require specific metabolic processes to occur, or the cells must divide to insert the lesion into the genetic code of the cell. We believe the cancer risk provides an extreme approximation to heritable mutations because cancer involves many types of cells whereas heritable mutations involve only germinal (reproductive) cells.

Table 4-17--Lifetime risk of death resulting from common activities and occupations for persons living in the United States

Activity	Time to accumulate a 1 in 1 million risk of death	Lifetime risk per capita[a]
Motor vehicle accident	1.5 days	1×10^{-2}
Falls	6 days	4×10^{-3}
Drowning	10 days	3×10^{-3}
Fires	13 days	2×10^{-3}
Firearms	36 days	7×10^{-4}
Electrocution	2 months	4×10^{-4}
Tornados	20 months	4×10^{-5}
Floods	20 months	4×10^{-5}
Lightning	2 years	3×10^{-5}
Animal bite or sting	4 years	2×10^{-5}
Everyday risks		
Eating and drinking[b]	40 diet sodas (saccharin) 6 pounds of peanut butter (aflatoxin) 180 pints of milk (aflatoxin) 200 gallons of drinking water from Miami or New Orleans 90 pounds of broiled steak (cancer risk only)	
Smoking	2 cigarettes	
Occupational risks		
General		
Manufacturing	4.5 days	2×10^{-3}
Trade	7 days	1×10^{-3}
Service and government	3.5 days	3×10^{-3}
Transport and public utilities	1 day	1×10^{-2}
Agriculture	15 hours	2×10^{-2}
Construction	14 hours	2×10^{-2}
Mining and quarrying	9 hours	3×10^{-2}
Specific		
Coal mining	14 hours	2×10^{-2}
Police duty	1.5 days	6×10^{-3}
Railroad employment	1.5 days	6×10^{-3}
Firefighting	11 hours	2×10^{-2}

[a]Assuming 30 years at risk for occupational risks, 70 years at risk for other risks.
[b]Amount needed to accumulate a one in a million risk of death.

Source: Adapted from Crouch and Wilson (1982).

Glyphosate, fenvalerate, metalaxyl, diphenamid, sethoxydim, and triadimefon tested negative for mutagenicity in all assays conducted, and thus can be considered to pose no mutagenic risk. Although there were a number of mutagenicity assays in which it tested positive, chlorpyrifos is considered by EPA to be nonmutagenic. Therefore, for this analysis, it is considered to be nonmutagenic. Dimethoate tested positive in a number of test systems, so it can be considered a potential human mutagen.

Simazine and napropamide were nonmutagenic in the great majority of assays conducted and were nononcogenic in all of the carcinogenicity tests performed; therefore, it can be assumed that their mutagenic risk is slight to negligible. Dicamba was nonmutagenic in most of the assays performed. Because of the bulk of negative results, dicamba can be considered as nonmutagenic in the risk analysis.

No EPA-validated mutagenicity studies have been conducted with DCNA, diazinon, or thiram, although no mutagenic effects were observed in three bacterial studies with DCNA and one for diazinon. For thiram fifteen of 17 studies found in the open literature were positive for mutagenicity. A conservative assumption is that all of these chemicals are mutagenic. The probability of causing heritable mutations is low because they have not been shown to cause cancer in any long-term studies.

Bifenox and DCPA also were nonmutagenic in all tests, so that the risk of heritable mutations is low even though there is some uncertainty indicated because EPA has not accepted the mutagenicity tests. As indicated in chapter 2, the risk of human mutations from captan is low or nonexistent. EPA has also concluded that chlorothalonil is not mutagenic in mammals.

Technical oxyfluorfen and its contaminant PCE have in some instances tested positive for mutagenicity. EPA (1981b) concluded that further study is required to define the mutagenicity of these compounds, but the worst case assumption made here is that oxyfluorfen is mutagenic. Benomyl has tested positive for mutagenicity in some assays and negative in others. Although EPA has decided that regulatory action is not warranted, the worst case assumption is that benomyl is a mutagen for humans. Maneb has tested positively and negatively in a variety of systems, but EPA (1985g) considers it to be mutagenic to mammals. The worst case estimate is made that the risk of heritable mutations from oxyfluorfen, benomyl, or maneb is no greater than the risk calculated for cancer.

Carbaryl may act as a weak mutagen (EPA 1984b), but EPA has concluded that present information does not indicate a mutagenic hazard to humans (EPA 1980). However, a worst case assumption would be that carbaryl does create some risk of heritable mutations, and this risk is not greater than the risk calculated for cancer.

Assays indicate that 1,3-dichloropropene may be mutagenic, so Vorlex must also be considered mutagenic, even though it has not been shown to be so in direct assays. Methyl bromide may be a weak mutagen, so methyl bromide and chloropicrin mixtures are considered here to be weakly

mutagenic to humans. The mutagenicity of the chloropicrin component is questionable. The risk of heritable mutations from 1,3-dichloropropene, methyl bromide and chloropicrin mixtures, and Vorlex should be no greater than the estimates of cancer risk based on a worst case approximation.

Dazomet is applied as a granular formulation so the potential for exposure is very limited. However, formaldehyde, a dazomet breakdown product, has been shown to be a weak mutagen. The risk of heritable mutations from formaldehyde exposure can be estimated to be no greater than that calculated for cancer. No mutagenicity studies have been reported for the dazomet breakdown products monomethylamine and hydrogen sulfide. The other principal active product of dazomet, MITC, has tested negative for mutagenicity.

Atrazine tested positive for mutagenicity in 15 of 33 assays. The worst case assumption is that atrazine is mutagenic. However, many of the positive results were achieved through tests that may not be relevant to evaluating mutagenic risk in humans. Some positive results in rodents were also achieved, but these in vivo responses were observed only at levels greater than 1,500 mg/kg body weight. These are exceptionally high levels and suggest that the degree of germ cell hazard from low levels of atrazine would be minimal.

For 2,4-D, there have been only a few studies performed and these have indicated both positive and negative results and thus questionable mutagenic potential. EPA has requested more mutagenicity test information for this compound. A number of comprehensive reviews of the 2,4-D mutagenic data have indicated that it does not pose significant risk of human gene mutations (USDA 1984). 2,4-D has been shown to be nononcogenic in the two carcinogenicity studies that have been conducted. Based on a worst case estimate, the risk of heritable mutations from these chemicals would be no greater than the estimates of cancer risk.

SYNERGISTIC EFFECTS

Synergistic effects of chemicals are those that occur from exposure to two chemicals either simultaneously or within a relatively short period of time. Forestry workers exposed to the fungicide thiram have experienced skin blotching and nausea from drinking alcoholic beverages within 10 days of their thiram exposure. Synergism occurs when the combined effects of the two chemicals cannot be predicted based on the known toxic effects of the individual chemicals or when their combined effect is much greater than the sum of the effects of either chemical given alone. For example, á mixture of the herbicides 2,4-D and picloram has produced skin irritation in test animals while neither herbicide alone has been found to be a skin irritant. Cigarette smoke and asbestos are both known carcinogens. When inhaled in combination they have been found to increase cancer risk eightfold above the risk of persons exposed to asbestos who do not smoke.

Evidence of Synergistic Effects from Pesticides

Instances of chemical combinations that cause synergistic effects are relatively rare. Kociba and Mullison (1985) in describing toxicological interactions with agricultural chemicals state the following:

> Our present scientific knowledge in toxicology indicates than an exposure to a mixture of pesticides is more likely to lead to additivity or antagonism rather than synergism when considering the toxicological effects of such a combination. To be conservative and for reasons of safety, an additive type of toxicological response is generally assumed rather than an antagonistic type of response.
>
> In the case of registered pesticides, a great amount of toxicological information is developed during the research and development of each individual pesticide. In addition to this information on individual pesticides, short term toxicity studies are always done prior to the selling of a pesticide mixture. Should synergism unexpectedly be present in a proposed commercial mixture of two pesticides, it would be identified in such cases and would then be dealt with accordingly. In toxicological tests involving a combination of commercial pesticides, synergism has generally not been observed.

Pesticide mixtures are generally not used in the Forest Service's nurseries. The two mixtures that are used, methyl bromide + chloropicrin and MITC + 1,3-dichloropropene (in Vorlex), have not shown synergistic effects in humans who have used them in nurseries and in other applications. In addition, there is no evidence from acute testing on these formulations that these mixtures are synergistic.

The toxic effects of the possible pesticide combinations other than the EPA registered commercial mixtures mentioned above have not been studied. Time and money normally limit toxicity testing to the first priority, the effects of the pesticides individually, and this type of information is not yet sufficient in some cases. Moreover, the combinations that could be tested are too numerous to make that testing feasible. The combinations of interest in this risk assessment include not only combinations of two or more of the 28 pesticides (there are 378 possible combinations of 28 pesticides taken two at a time), but also combinations of the pesticides with other chemicals that exist in the environment. Based on the limited amount of data available on pesticide combinations, it is possible but very unlikely that synergistic effects could occur as a result of exposure to two or more of the pesticides considered in this analysis.

Likelihood of Exposures to Two Pesticides

It is possible that synergistic adverse effects could result from exposure to more than one pesticide applied in separate nursery applications because the nurseries are treated in a manner similar to

conventional agriculture. Pesticide residues may persist in plants and soil from one application to another.

However, the 28 pesticides are known to be rapidly excreted from the body. None of the pesticides has been found to accumulate in test animal body tissues, so exposure of an individual to two pesticides, even within a relatively short time, would be unlikely to simultaneously cause significant levels of residues within the body.

Third, public exposures to the pesticides should be low except for accidents and should occur only very infrequently. The probability of a larger accidental exposure to any single pesticide is extremely low. Because the probability of a member of the public receiving a large exposure is so low for one pesticide, the probability of simultaneous large exposures to two pesticides is negligible. This is because the probability of two independent events occurring simultaneously is the product of the probabilities of the individual events. For example, if the probability of a person receiving a given exposure is 1 in 1,000 for each of two pesticides, then the probability of receiving that exposure to both pesticides would be 1 in 1 million.

Risks from Pesticide Mixtures

Simultaneous exposure to more than one chemical is likely in the cases of methyl bromide and chloropicrin use and the use of Vorlex. These mixtures have been approved for use by the Environmental Protection Agency.

The EPA guidelines for assessing the risk from exposures to chemical mixtures (EPA 1986i) recommend using additivity models when little information exists on the toxicity of the mixture and when components of the mixture appear to induce the same toxic effect by the same mode of action. They suggest in their discussion of interactions (synergistic or antagonistic effects) of chemical mixtures that "there seems to be a concensus that for public health concerns regarding causative (toxic) agents, the additive model is more appropriate [than any multiplicative model]."

The EPA guidelines suggest using a hazard index (HI) as the model of additivity based on the dose and toxicity reference level (NOEL) for each chemical as follows:

$$HI = D_1/L_1 + D_2/L_2$$

where

D_i is the dose of the i^{th} component and
L_i is the toxicity reference level (NOEL)

As HI approaches 1, the risk from the mixture becomes greater. On the basis of the highest exposures for adult members of the public in this risk assessment (accidental exposures) for systemic effects for methyl bromide + chloropicrin, it appears that the risk from the mixture is twice as great as that from the constituents alone. For Vorlex, it appears that the

risk from the mixture is only slightly higher than the risk from 1,3-dichloropropene alone.

Although the pesticides used for vegetation control are unlikely to have synergistic toxic effects, other substances occurring in the diets of exposed people may have some influence on the toxicity of the pesticides. This is one of several factors that may influence the sensitivity of individuals.

EFFECTS ON SENSITIVE INDIVIDUALS

Individual Sensitivity

Doull et al. (1980) describe "hypersensitivity" as the response of subjects at the lower end of the frequency distribution in a quantal dose-response curve. Quantal means a subject either exhibits the toxic response or does not, at a given dose level. If the response of a population of test animals to varying doses of a chemical follows a normal distribution (bell-shaped curve), the hypersensitive individuals are those on the left hand side of the curve that respond at much lower doses than the average. For example, if the average individual responds with toxic symptoms at a dose of 100 mg/kg and the standard deviation of the response is 30 mg/kg, then about 95 percent of the individuals will have responded with those symptoms at doses from 40 to 160 mg/kg; more than 99 percent at doses from 10 to 190 mg/kg. Less than .15 percent of the population will have experienced toxicity at doses lower than 10 mg/kg. Applying this distribution of response to humans would mean that in a population of 10,000, fewer than 15 individuals would be likely to experience toxicity at doses lower than 10 mg/kg. Those 15 individuals could be considered the sensitive individuals in the population.

Although a safety factor of 10 traditionally has been used by regulatory agencies (NAS 1977) to account for intraspecies (that is interindividual) variation, Calabrese (1985) has shown that human susceptibility to toxic substances can vary two to three orders of magnitude. Calabrese examined a number of studies of human responses to chemicals and found that the safety factor of 10 accounts for effects in 80 to 95 percent of a population. Thus 5 to 20 percent of the population exhibit effects at doses outside the tenfold range.

Factors Affecting the Sensitivity of Individuals

Factors that may affect individual susceptibility to toxic substances include diet, age, heredity, preexisting diseases, and life style (Calabrese 1978). These factors have been studied in detail for very few cases, and their significance in controlling the toxicity of the proposed pesticides is not known. However, enough data have been collected on other chemicals to show that these factors can be important.

Elements of the diet known to affect toxicity include vitamins and minerals (Calabrese and Dorsey 1984). For example, the mineral selenium can prevent the destruction of blood-forming tissues by chronic heavy

exposure to benzene. Large doses of vitamin C have also been shown to protect animals and humans from toxic effects of chronic benzene exposure. Vitamin A seems to have a preventative effect on cancer induced by chemicals such as benzo(a)pyrene (found in cigarette and wood smoke) and DMBA. This effect has been seen in laboratory animals and human epidemiological studies. The food additives BHT and BHA may also be active in preventing the carcinogenicity of benzo(a)pyrene. Various levels of the B vitamin riboflavin have also been tested with mixed results. Vitamin C has been shown to prevent nitrites from combining with amines to form nitrosamines, and vitamin E seems to be at least as effective. These vitamins would be likely to prevent formation of N-nitrosoatrazine and N-nitrosoglyphosate if conditions were otherwise favorable for their formation in the human stomach (Calabrese and Dorsey 1984).

Genetic factors are also known in some cases to be important determinants of susceptibility to toxic environmental agents (Calabrese 1984). Susceptibility to irritants and allergic sensitivity vary widely among individuals and are known to be largely dependent on genetic factors. Race has been shown to be a significant factor influencing sensitivity to irritants, and some investigations have indicated that women may be more sensitive than men (Calabrese 1984).

A variety of human genetic conditions have been identified as possibly enhancing susceptibility to environmental agents. For example, persons with beta-thalassenia may be at increased risk when exposed chronically to benzene. However, only one condition, G-6-PD deficiency, has conclusively been demonstrated to cause enhanced susceptibility to industrial pollutants. Several other genetic conditions have been shown to involve defects in the cellular mechanisms for repair of damage to DNA. Persons with these diseases share an increased sensitivity to the effects of ultraviolet light, which can cause cancer. Cells from individuals with at least one of these diseases, xeroderma pigmentosum, are also sensitive to a variety of chemical substances implicated as causative agents of human cancers (Calabrese 1984).

Persons with other types of preexisting medical conditions may also be at increased risk of toxic effects. For example, sensitivity to chemical skin irritants can be expected to be greater for people with a variety of chronic skin ailments. Patients with these conditions may be advised to avoid occupational exposure to irritating chemicals (Shmunes 1980, as cited in Calabrese 1984).

Allergic Hypersensitivity

A particular form of sensitivity reaction to a foreign substance is allergic hypersensitivity. Allergic hypersensitive reactions may be immediate, such as in anaphylaxis reactions to insect bites or penicillin injections; or they may be delayed as in the case of immune responses to tuberculin tests or contact dermatitis caused by poison ivy. The severe, immediate anaphylaxis reactions, which can be fatal if not treated within minutes, are antigen-antibody reactions that require large, complex organic molecules to initiate the sensitivity. The delayed allergic hypersensitive

reactions are usually directed against whole cells (bacteria, viruses, fungi) but, as in contact dermatitis, may be induced by lower molecular weight substances such as the catechols of poison ivy, cosmetics, drugs, or antibiotics (Volk and Wheeler 1983). Benzocaine, neomycin, formaldedhyde, nickel, chromium, and thiram are all known to produce these reactions (Marzulli and Maibach 1983).

Likelihood of Effects in Sensitive Individuals

Based on the current state of knowledge, individual susceptibility to the toxic effects of the 10 pesticides cannot be specifically predicted. As discussed above, safety factors have traditionally been used to account for variations in susceptibility among people. The margin-of-safety approach used in this risk assessment takes into account much of the variation in human response as discussed earlier by Calabrese (1985). As described in the introduction to this risk assessment, a safety factor of 10 is used for interspecies variation, an additional safety factor of 10 is used for within-species variation.

Thus, the normal margin of safety of 100 for both types of variation is generally sufficient to ensure that the majority of people should experience no toxic effects. However, sensitive individuals may experience effects even when the margin of safety is equal to or greater than 100. In particular, in instances in the risk assessment where margins of safety are less than 100 for an exposure to a particular pesticide, it is likely that any exposed sensitive individuals would experience toxic effects, whereas the average person may not. It must be noted, however, that sensitive individuals comprise only a fraction of the population at large and that it is not likely that a sensitive individual would be among those few people who might be exposed in any of the applications done by the Forest Service. It must also be noted that the great majority of public exposures that have been estimated to occur in this risk assessment are very low and in most applications that will actually occur when the program is implemented no member of the public is liable to be exposed.

None of the pesticides used in the Forest Service nurseries is of high molecular weight, so the immediate allergic reactions and the delayed allergic reactions except for contact dermatitis can be ruled out as possible toxic effects. There may be some people who develop contact dermatitis from pesticide exposure, but this type of reaction would most likely be limited to workers who handle the pesticides regularly and are exposed to relatively large amounts on a number of occasions. The small, infrequent exposures of the public should limit the possibility of their acquiring this type of reaction.

CUMULATIVE EFFECTS

Cumulative effects are not likely to occur because none of the pesticides is persistent in the environment or in the human body, no member of the public is likely to be chronically exposed from nursery applications, and no member of the public is likely to receive simultaneous exposures from these same pesticides used in any other programs.

There are instances when it could be argued that cumulative doses would occur. If a nursery is resprayed with a pesticide before the pesticide from the previous spraying has been totally degraded, or if another use of the same pesticide occurs in the same nursery and overlaps its degradation in time, then it is possible for larger pesticide doses to occur than from a single application. Cumulative exposure could also occur when an individual who uses one of the pesticides in their lawn or garden work or is exposed to a pesticide from nearby agricultural areas is exposed to the same pesticide as a result of the Forest Service nursery application program.

Pesticide doses from the other types of sources mentioned above were not estimated in the risk assessment. However, the risks of adverse health effects from possible cumulative doses in this program should be no greater than the risks from routine-extreme exposures. The assumptions used in the risk assessment overestimate exposures from eating, drinking, and coming in contact with vegetation. These estimates are conservative enough to cover exposure from these other sources, so the risks from possible hypothetical cumulative exposures should be no greater than the risks already discussed in this assessment.

References Cited

All documents cited in this document are available at universities, at libraries, or from Federal agencies such as the Forest Service or the U.S. Environmental Protection Agency (EPA). All EPA documents can be obtained through requests to EPA's Freedom of Information Office, Washington, DC 20460.

In the text of this document, references are cited in parentheses using the author-year system of citation. When an organization (such as a Government agency or scientific society) is listed as the author in the parenthetical citation, an acronym or an abbreviated form of that organization's name generally is used in place of its full title. Below is a list of acronyms and abbreviations that are used in citations, along with the corresponding full titles that are used in this reference section.

BLM	U.S. Department of the Interior, Bureau of Land Management
EPA	U.S. Environmental Protection Agency
HSDB	Hazardous Substances Data Bank
IARC	International Agency for Research on Cancer
NCI	National Cancer Institute
NIOSH	National Institute for Occupational Safety and Health
NLM	National Library of Medicine
OSTP	U.S. Office of Science and Technology Policy
RTECS	Registry of Toxic Effects of Chemical Substances
USDA	U.S. Department of Agriculture, Forest Service
WHO	World Health Organization
WSSA	Weed Science Society of America

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Appendix I

Worker Exposure Studies of Fumigators and Tarp Lifters

The following are summaries of worker exposure studies from the California Department of Agriculture that were used to estimate exposure concentrations for nursery fumigators using methyl bromide and chloropicrin.

Maddy et al. (1982) measured methyl bromide concentrations in the breathing zones of workers during soil fumigation projects. Methyl bromide was applied at rates of 214 to 375 lb/acre. A tarp was applied to the soil surface as the fumigant was injected to a depth of 8 inches. Samples were collected over periods of approximately 30 minutes. The measured concentrations for the three categories of workers were as follows: tractor driver, 0.29 to 5.26 ppm, average 2.17 ppm; copilot, below detection limit to 7.42 ppm, average 2.97 ppm; and shoveler, below detection limit to 2.25 ppm, average 0.67 ppm.

None of the values were greater than the 15 ppm permissable exposure limit (PEL) set by the California Occupational Safety and Health Administration. Only 3 of the 40 measurements were greater than 5 ppm, which is the threshold limit value (TLV). The TLV is a time-weighted average (TWA) for an 8-hour day set by the American Conference of Governmental Industrial Hygienists (ACGIH). TWA's were not calculated for this study.

Maddy et al. (1983a) measured methyl bromide and chloropicrin concentrations in operations similar to those described above. Application rates were 300 lb/acre for a 67-percent methyl bromide and 33-percent chloropicrin mixture and 275 lb/acre for a 75-percent methyl bromide and 25-percent chloropicrin mixture. Air sampling periods were approximately 45 minutes. Methyl bromide values ranged from nondetectable to 6.3 ppm, and averages were 1.45 ppm for tractor drivers, 1.6 ppm for copilots, and 0.7 ppm (one sample) for shovelers. Chloropicrin values ranged from nondetectable to 181 parts per billion (ppb), and averages were 69 ppb for tractor drivers, 41 ppb for copilots, and 45 ppb (one sample) for shovelers.

Time-weighted averages were calculated when at least two measurements were made during a fumigation project. For methyl bromide, the TWA's were 1.4 ppm for tractor drivers and 1.6 ppm for copilots. The TWA's for chloropicrin were 69 ppb for tractor drivers and 41 ppb for copilots. The TWA's for chloropicrin were below the TLV of 100 ppb recommended by ACGIH and the short-term exposure limit (STEL) of 300 ppb.

Maddy et al. (1984a) again performed breathing zone monitoring studies of workers using methyl bromide and chloropicrin in three preplant soil fumigation projects. Air samples were collected for 1- to 2-hour periods. The fumigant was applied at a rate of 275 lb/acre with 75-percent methyl bromide and 25-percent chloropicrin.

The results of the monitoring study showed higher levels of both fumigants than the previously described studies. Sampling periods of about 1 hour from two fumigation projects had values of methyl bromide ranging from 3.1 to 5.0 ppm for drivers and 3.8 to 8.3 ppm for copilots. Chloropicrin values ranged from 90 to 154 ppb for drivers and 86 to 190 ppb for copilots. TWA's for methyl bromide were 1.2 ppm (driver) and 1.9 ppm (copilot), and they were 35 ppb (driver) and 50 ppb (copilot) for chloropicrin.

Methyl bromide values measured from a fourth fumigation project were invalidated because of errors in sampling. Chloropicrin values collected for 2-hour periods were very high: 1,186 ppb and 1,544 ppb for drivers and 474 ppb and 608 ppb for copilots. Chloropicrin samples for 1-hour periods were much lower and closer to those values obtained in the first two projects: 244 ppb for drivers and 116 ppb for copilots. TWA's for chloropicrin were 730 ppb for drivers and 294 ppb for copilots.

The following studies were used to estimate exposures to fumigators using Vorlex or 1,3-dichloropropene.

Maddy et al. (1984b) monitored the breathing zones of workers applying Telone (1,3-dichloropropene) as a preplant soil fumigant. Application rates were between 4.5 and 20 gal/acre. The TWA's for an 8-hour period ranged from 0.07 to 3.61 ppm, with an average of 0.71 ppm. Some of the TWA's exceeded the PEL of 1 ppm, but the average TWA was below this limit.

The effectiveness of using respirators to reduce exposure was calculated as a protection factor, which is the ratio of the ambient concentration to the concentration inside the respirator. For 14 measurements in 8 operations, the mean protection factor was 192, the range was 10 to 990, and the standard deviation was 294.

Maddy et al. (1980) measured air concentrations of Telone or DD during 19 soil injection operations using application rates of 2 to 20 gallons per acre. Concentrations in the tractor driver's breathing zone averaged approximately 380 ppb. Only one measurement was above 1,000 ppm (1 ppm). For a transfer operation, concentrations of Telone in the breathing zone of loaders were 356 ppb, but they were only 14 ppb inside the respirator.

The following studies were used to estimate methyl bromide + chloropicrin exposure to tarp lifters.

Atmospheric concentrations of methyl bromide were measured during the fumigation of bowling greens. Concentrations in the operators' breathing zone were as follows: 75 ppm at the time of application, 20 to 450 ppm during the loosening of the tarp, and 50 to 75 ppm when rolling up the tarp. Concentrations were 450 ppm at a tear in the sheet, 500 ppm at 10 feet, and 80 ppm at 25 feet (Simpson 1967, as cited in USDA 1986b).

Methyl bromide exposures to workers removing plastic tarps have also been measured 5 to 9 days after applications to greenhouse soils (Van Den Oever 1982). The mean methyl bromide concentration experienced by workers removing tarps in open greenhouses was 30 ppm. Average values experienced

in 5 cases ranged from 10 to 50 ppm. Peak values were as high as 200 ppm. However, the methyl bromide application rate was relatively high: 714 lb/acre (80 g/m^2).

Appendix II
Individual Forest Service Nursery
Pesticide Risk Assessments

A. Albuquerque Nursery

B. Ashe Nursery

C. Bend Pine Nursery

D. Bessey Nursery

E. Coeur d'Alene Nursery

F. Humboldt Nursery

G. Lucky Peak Nursery

H. Placerville Nursery

I. Stone Nursery

J. Toumey Nursery

K. Wind River Nursery

A. Albuquerque Nursery

EXPOSURE ANALYSIS METHODS

The Albuquerque Nursery, which is located in New Mexico, has a total area of 222 acres and a total nursery bed area of 81 acres. Approximately 165 acres are treated with pesticides every year. The nursery generally employs the following number of personnel annually for its operations: 1 to 9 mixer/loader/applicators, 11 to 24 weeders, 6 to 9 inventory personnel, 100 to 120 lifters, 100 to 120 sorters and packers, 8 fumigators, and 6 to 8 tarp lifters.

The exposure analysis methods used to estimate doses to workers and the public in the Albuquerque Nursery were similar to those described for the generic nursery, except that conditions specific to the nursery, such as the pesticides used, the application rates, and the timing of the applications, were used in the analyses rather than the generic set of conditions. As indicated in table A-1, the pesticide application schedule for the nursery is incomplete and no other information is currently available. (Tables can be found at the end of this section.) To determine foliar washoff of pesticide residues, each bed was assumed to be irrigated every other day at a rate of 0.25 inches per day. Methyl bromide + chloropicrin is applied in mid-June at a rate of 350 lb/acre.

There is one Forest Service residence onsite and no other residences within 3 miles of the nursery boundary. The land bordering the nursery includes Kirtland Air Force Base, the Zia Gun Club, the City of Albuquerque, and the University of New Mexico.

The nearest live water is a river approximately 5 miles from the nursery boundary. An aquifer is located at a depth of 340 feet. The nursery soil is sandy loam.

RISK ANALYSIS

Risk of Systemic and Reproductive Effects

Risks to members of the public and workers involved in pesticide applications and related nursery tasks in the Albuquerque Nursery are based on the methods described in chapters 3 and 4 of the risk assessment. Tables A-2 and A-3 present exposure levels and margins of safety based on LD_{50}'s, systemic NOEL's, and reproductive NOEL's for bifenox and 2,4-D routine-realistic (average), routine-extreme, and accidental exposures. Captan exposure is to seed treaters only. The discussion of those exposures is presented in chapter 3.

The MOS tables consist of two parts. The first lists worker exposures and MOS's for each chemical as it is used in the Albuquerque Nursery. The worker portion lists MOS's for routine-realistic (average), routine-extreme (extreme), and accidental exposures (spraying, spills on the skin, and premature reentry). LD_{50}'s and NOEL's are listed above each column of MOS's.

The second portion of the table lists public exposures and MOS's via specific exposure routes for routine-realistic (average) and routine-extreme (lowest MOS's) exposures.

Dashes in the worker portion of the tables indicate that the chemical is used only in cover crops. Dashes in the public portion indicate that the route of exposure is not considered a significant one in this analysis. Margins of safety greater than 1,000 are indicated by ++.

Where MOS's are greater than 100, risk can be considered negligible for the chemical in question. MOS's between 10 and 100 indicate slight risk of low-level toxic effects--to sensitive individuals in particular. MOS's between 1 and 10 indicate moderate risk of low-level toxic effects, especially in light of the uncertainty in extrapolating from laboratory test animal species to humans. Risk may be significant where an MOS for a chemical is negative (the estimated exposure exceeds the animal NOEL). Refer to the discussion of low-level toxic effects in the generic nursery risk analysis.

Cancer Risk

Lifetime cancer risks for 2,4-D exposure to members of the public at the Albuquerque Nursery are listed in table A-4 for different exposure routes and number of lifetime exposures. Lifetime cancer risk to workers from the use of 2,4-D in various nursery tasks are listed in table A-5. The cancer risk tables should be interpreted as follows. Where the exponent is lower, the risk is higher. For example, a risk value of 1.0E-06 (1 chance in 1 million) is lower than a risk of 1.0E-05 (1 chance in 100,000). A risk of 7.0E-06 exceeds a risk of 1.0E-06.

In general, risk may be considered acceptable where risk to an individual is equal to or lower than 1 in 1 million. Where risk exceeds 1 chance in 100,000, proper precautions that reduce exposure levels may, in turn, reduce the cancer risk to acceptable levels.

Table A-1--Albuquerque Nursery schedule for pesticide applications (based on average use)

Crop	Year	Chemical	Acres	Rate (lb/acre)	Applications per year	Month of application
Cover crop	0	2,4-D	81	1.2	6	Apr-Sep
Pine	1	Bifenox	30	1.0	1	Jul
Seed treatment		Captan		1 tsp/gal water		Before sowing

Table A-2--Margins of safety for workers
Nursery: Albuquerque
Pesticide: Bifenox

	Exposure (mg/kg/day)	Margin of safety relative to: LD_{50} (6400.0)	Systemic NOEL (12.50)	Reproductive NOEL (10.00)
Average				
Applicator	0.0063	++	++	++
Weeder	0.0033	++	++	++
Inventory	0.0069	++	++	++
Lifting	0.0000	++	++	++
Extreme				
Applicator	0.0140	++	900	720
Weeder	0.0734	++	170	140
Inventory	0.1348	++	93	74
Lifting	0.0000	++	++	++
Accident spray	0.4200	++	30	24
Accident spill	120.0000	53	-9.6	-12
Premature reentry	0.1703	++	73	59

Margins of Safety for Exposed Members of the Public

	Exposure (mg/kg/day)	Margin of safety relative to: LD_{50} (6400.0)	Systemic NOEL (12.50)	Reproductive NOEL (10.00)
Average over applications				
Dietary exposures				
Beef	0.0001	++	++	++
Rabbit	0.0017	++	++	++
Grouse	0.0014	++	++	++
Vegs., 25 feet	0.0047	++	++	++
Vegs., 100 feet	0.0032	++	++	++
Water, runoff	---	---	---	---
Water, drift	---	---	---	---
Dermal exposures				
At 25 feet	0.0014	++	++	++
At 100 feet	0.0009	++	++	++
Dog petting	0.0001	++	++	++
Lowest margins of safety				
Dietary exposures				
Beef	0.0001	++	++	++
Rabbit	0.0017	++	++	++
Grouse	0.0014	++	++	++
Vegs., 25 feet	0.0047	++	++	++
Vegs., 100 feet	0.0032	++	++	++
Water, runoff	---	---	---	---
Water, drift	---	---	---	---
Dermal exposures				
At 25 feet	0.0014	++	++	++
At 100 feet	0.0009	++	++	++
Dog petting	0.0001	++	++	++

Table A-3--Margins of safety for workers
Nursery: Albuquerque
Pesticide: 2,4-D

	Exposure (mg/kg/day)	Margin of safety relative to: LD_{50} (375.0)	Systemic NOEL (1.00)	Reproductive NOEL (5.00)
Average				
Applicator	0.0122	++	82	410
Weeder	---	---	---	---
Inventory	---	---	---	---
Lifting	---	---	---	---
Extreme				
Applicator	0.0271	++	37	180
Weeder	---	---	---	---
Inventory	---	---	---	---
Lifting	---	---	---	---
Accident spray	0.3000	++	3.3	17
Accident spill	140.0000	2.7	-140	-28
Premature reentry	---	---	---	---

Margins of Safety for Exposed Members of the Public

	Exposure (mg/kg/day)	Margin of safety relative to: LD_{50} (375.0)	Systemic NOEL (1.00)	Reproductive NOEL (5.00)
Average over applications				
Dietary exposures				
Beef	0.0001	++	++	++
Rabbit	0.0019	++	530	++
Grouse	0.0015	++	670	++
Vegs., 25 feet	0.0056	++	180	890
Vegs., 100 feet	0.0039	++	260	++
Water, runoff	---	---	---	---
Water, drift	---	---	---	---
Dermal exposures				
At 25 feet	0.0010	++	1000	++
At 100 feet	0.0007	++	++	++
Dog petting	0.0001	++	++	++
Lowest margins of safety				
Dietary exposures				
Beef	0.0001	++	++	++
Rabbit	0.0019	++	530	++
Grouse	0.0015	++	670	++
Vegs., 25 feet	0.0056	++	180	890
Vegs., 100 feet	0.0039	++	260	++
Water, runoff	---	---	---	---
Water, drift	---	---	---	---
Dermal exposures				
At 25 feet	0.0010	++	1000	++
At 100 feet	0.0007	++	++	++
Dog petting	0.0001	++	++	++

Table A-4--Lifetime cancer risk for exposed members of the public at the Albuquerque Nursery

	2,4-D
5 Exposures	
Rabbit	1.E-08
Vegs. (25 ft)	3.E-08
Water, drift	----
Dermal (25 ft)	6.E-09
30 Exposures	
Rabbit	7.E-08
Vegs. (25 ft)	2.E-07
Water, drift	----
Dermal (25 ft)	3.E-08

Table A-5--Lifetime cancer risk for workers
Nursery: Albuquerque

	2,4-D
5 Years of exposure	
Weeding	----
Inventory	----
Lifting	----
Application	6.E-07
30 Years of exposure	
Weeding	----
Inventory	----
Lifting	----
Application	3.E-06

B. Ashe Nursery

EXPOSURE ANALYSIS METHODS

The Ashe Nursery, located in Mississippi, has a total area of 410 acres and a total nursery bed area of 125 acres. All 125 bed-acres are treated with pesticides every year. The nursery generally employs the following number of personnel annually for its operations: 10 to 14 mixer/loader/applicators, 11 to 24 weeders, 2 inventory personnel, 40 to 60 lifters, 20 to 60 sorters and packers, 3 fumigators, and 4 tarp lifters.

The exposure analysis methods used to estimate doses to workers and the public in the Ashe Nursery were similar to those described for the generic nursery, except that conditions specific to the nursery, such as the pesticides used, the application rates, and the timing of the applications, were used in the analyses rather than the generic set of conditions. The pesticide application schedule for the nursery is given in table B-1. (Tables can be found at the end of this section.) For the purposes of determining foliar washoff of pesticide residues, each bed was assumed to be irrigated every other day at a rate of 0.5 inches per day. Approximately 85 acres are fumigated in March with methyl bromide + chloropicrin, 1,3-dichloropropene, or Vorlex. Generally, the nursery stock is lifted at the end of the first year of growth.

In the Ashe Nursery the roots of longleaf pine seedlings are treated before storing and outplanting with a slurry mixture of the fungicide benomyl and kaolin clay. About 500 seedlings are first packed into plastic-lined breathable paper bags. The slurry is then applied by inserting the hose into the bag. The applicator must wear rubber gloves and an apron during this procedure. The bags are then sealed and kept in cold storage at a temperature of 34 °F until the time of outplanting. Any residues on the trees at the time of lifting and packing will also be available to the seedling outplanter. This overestimates exposure as it assumes no degradation will occur under refrigerated conditions and that the plants are immediately refrigerated after treatment.

There is one Forest Service residence onsite, but no other residences are located within one half of a mile of the nursery boundary. All of the land bordering the nursery is forested.

The nearest live water is a creek approximately 2 miles from the nursery. An aquifer is located at a depth of 120 feet. The nursery soil is sandy loam.

RISK ANALYSIS

Risk of Systemic and Reproductive Effects

Risks to members of the public and workers involved in pesticide applications and related nursery tasks in the Ashe Nursery are based on the methods described in chapters 3 and 4 of the generic nursery risk assessment. Tables B-2 through B-13 present exposure levels and margins of

safety based on LD_{50}'s, systemic NOEL's, and reproductive NOEL's for routine-realistic (average), routine-extreme, and accidental exposures.

The MOS tables for each chemical consist of two parts. The first lists worker exposures and MOS's for the chemical as it is used in the Ashe Nursery. The worker portion lists MOS's for routine-realistic (average), routine-extreme (extreme), and accidental exposures (spraying, spills on the skin, and premature reentry). LD_{50}'s and NOEL's are listed above each column of MOS's.

The second portion of each table lists public exposures and MOS's via specific exposure routes for routine-realistic (average) and routine-extreme (lowest MOS's) exposures. The only accidents that may affect the public are assumed to be those involving fumigant spills. The analysis of fumigant spills is contained in the generic nursery risk analysis.

Dashes in the worker portion of the tables indicate that the chemical is used only in cover crops. Dashes in the public portion indicate that the route of exposure is not considered a significant one in this analysis. Margins of safety greater than 1,000 are indicated by ++.

Where MOS's are greater than 100, risk can be considered negligible for the chemical in question. MOS's between 10 and 100 indicate a slight risk of low-level toxic effects--to sensitive individuals in particular. MOS's between 1 and 10 indicate moderate risk of low-level toxic effects, especially in light of the uncertainty in extrapolating from laboratory test animal species to humans. Risk may be significant where an MOS for a chemical is negative (the estimated exposure exceeds the animal NOEL). Refer to the discussion of low-level toxic effects in the generic nursery risk analysis.

Cancer Risk

Lifetime cancer risks for known or suspected carcinogenic chemicals to members of the public at the Ashe Nursery are listed in table B-14 for different exposure routes and numbers of lifetime exposures. Lifetime cancer risk to workers from the use of those chemicals in various nursery tasks are listed in table B-15. The cancer risk tables should be interpreted as follows. Where the exponent is lower, the risk is higher. For example, a risk value of 1.0E-06 (1 chance in 1 million) is lower than a risk of 1.0E-05 (1 chance in 100,000). A risk of 7.0E-06 exceeds a risk of 1.0E-06.

In general, risk may be considered acceptable where risk to an individual is equal to or lower than 1 in 1 million. Where risk exceeds 1 chance in 100,000, proper precautions that reduce exposure levels may, in turn, reduce the cancer risk to acceptable levels.

Table B-1--Ashe Nursery schedule for pesticide applications (based on average use)

Crop	Year	Chemical	Acres	Rate (lb/acre)	Applications per year	Month of application
Cover Crop	0	Atrazine	70	2.0	1	Jun
Pine	1	Bifenox	20	3.0	1	Apr
Pine	1	Oxyfluorfen	85	0.5	6	Apr-Aug, Oct
Pine	1	Napropamide	65	0.5	1	Apr
Pine	1	Captan	85	1.5	1	Apr
Pine	1	Diazinon	85	0.5	3	Apr, Jul-Aug
Pine	1	Triadimefon	50	0.5	4	Apr-Jun
Pine	1	Sethoxydim	85	0.4	2	May-Jun
Pine	1	Simazine	15	2.0	1	May
Pine	1	Benomyl	85	0.5	7	May, Jul, Sept-Nov
Pine	1	Glyphosate	85	0.1	1	May
Pine	1	Chlorothalonil	85	1.5	2	Jun, Aug
Pine seedlings Root treatment	--	Benomyl	--	--	1	Before storing and outplanting

Table B-2--Margins of safety for workers
Nursery: Ashe
Pesticide: Atrazine

	Exposure (mg/kg/day)	Margin of safety relative to: LD_{50} (1869.0)	Systemic NOEL (3.70)	Reproductive NOEL (100.00)
Average				
Applicator	0.0293	++	130	++
Weeder	---	---	---	---
Inventory	---	---	---	---
Lifting	---	---	---	---
Extreme				
Applicator	0.0651	++	57	++
Weeder	---	---	---	---
Inventory	---	---	---	---
Lifting	---	---	---	---
Accident spray	0.8300	++	4.5	120
Accident spill	240.0000	7.8	-65	-2.4
Premature reentry	---	---	---	---

Margins of Safety for Exposed Members of the Public

	Exposure (mg/kg/day)	Margin of safety relative to: LD_{50} (1869.0)	Systemic NOEL (3.70)	Reproductive NOEL (100.00)
Average over applications				
Dietary exposures				
Beef	0.0002	++	++	++
Rabbit	0.0034	++	++	++
Grouse	0.0028	++	++	++
Vegs., 25 feet	0.0094	++	390	++
Vegs., 100 feet	0.0064	++	580	++
Water, runoff	---	---	---	---
Water, drift	---	---	---	---
Dermal exposures				
At 25 feet	0.0029	++	++	++
At 100 feet	0.0018	++	++	++
Dog petting	0.0002	++	++	++
Lowest margins of safety				
Dietary exposures				
Beef	0.0002	++	++	++
Rabbit	0.0034	++	++	++
Grouse	0.0028	++	++	++
Vegs., 25 feet	0.0094	++	390	++
Vegs., 100 feet	0.0064	++	580	++
Water, runoff	---	---	---	---
Water, drift	---	---	---	---
Dermal exposures				
At 25 feet	0.0029	++	++	++
At 100 feet	0.0018	++	++	++
Dog petting	0.0002	++	++	++

Table B-3--Margins of safety for workers
Nursery: Ashe
Pesticide: Bifenox

	Exposure (mg/kg/day)	Margin of safety relative to: LD_{50} (6400.0)	Systemic NOEL (12.50)	Reproductive NOEL (10.00)
Average				
Applicator	0.0125	++	1000	800
Weeder	0.0039	++	++	++
Inventory	0.0097	++	++	1000
Lifting	0.0000	++	++	++
Extreme				
Applicator	0.0279	++	450	360
Weeder	0.1762	++	71	57
Inventory	0.3797	++	33	26
Lifting	0.0000	++	++	++
Accident spray	1.3000	++	9.6	7.7
Accident spill	120.0000	53	-9.6	-12
Premature reentry	0.5095	++	25	20

Margins of Safety for Exposed Members of the Public

	Exposure (mg/kg/day)	Margin of safety relative to: LD_{50} (6400.0)	Systemic NOEL (12.50)	Reproductive NOEL (10.00)
Average over applications				
Dietary exposures				
Beef	0.0002	++	++	++
Rabbit	0.0052	++	++	++
Grouse	0.0042	++	++	++
Vegs., 25 feet	0.0140	++	890	710
Vegs., 100 feet	0.0097	++	++	1000
Water, runoff	---	---	---	---
Water, drift	---	---	---	---
Dermal exposures				
At 25 feet	0.0043	++	++	++
At 100 feet	0.0028	++	++	++
Dog petting	0.0003	++	++	++
Lowest margins of safety				
Dietary exposures				
Beef	0.0002	++	++	++
Rabbit	0.0052	++	++	++
Grouse	0.0042	++	++	++
Vegs., 25 feet	0.0140	++	890	710
Vegs., 100 feet	0.0097	++	++	1000
Water, runoff	---	---	---	---
Water, drift	---	---	---	---
Dermal exposures				
At 25 feet	0.0043	++	++	++
At 100 feet	0.0028	++	++	++
Dog petting	0.0003	++	++	++

Table B-4--Margins of safety for workers
Nursery: Ashe
Pesticide: Glyphosate

		Margin of safety relative to:		
	Exposure (mg/kg/day)	LD_{50} (4320.0)	Systemic NOEL (30.00)	Reproductive NOEL (10.00)
Average				
Applicator	0.0018	++	++	++
Weeder	0.0004	++	++	++
Inventory	0.0024	++	++	++
Lifting	0.0000	++	++	++
Extreme				
Applicator	0.0040	++	++	++
Weeder	0.0078	++	++	++
Inventory	0.0056	++	++	++
Lifting	0.0000	++	++	++
Accident spray	0.0420	++	710	240
Accident spill	180.0000	24	-6.0	-18
Premature reentry	0.0170	++	++	590

Margins of Safety for Exposed Members of the Public

		Margin of safety relative to:		
	Exposure (mg/kg/day)	LD_{50} (4320.0)	Systemic NOEL (30.00)	Reproductive NOEL (10.00)
Average over applications				
Dietary exposures				
Beef	0.0000	++	++	++
Rabbit	0.0002	++	++	++
Grouse	0.0001	++	++	++
Vegs., 25 feet	0.0005	++	++	++
Vegs., 100 feet	0.0003	++	++	++
Water, runoff	---	---	---	---
Water, drift	---	---	---	---
Dermal exposures				
At 25 feet	0.0001	++	++	++
At 100 feet	0.0001	++	++	++
Dog petting	0.0000	++	++	++
Lowest margins of safety				
Dietary exposures				
Beef	0.0000	++	++	++
Rabbit	0.0002	++	++	++
Grouse	0.0001	++	++	++
Vegs., 25 feet	0.0005	++	++	++
Vegs., 100 feet	0.0003	++	++	++
Water, runoff	---	---	---	---
Water, drift	---	---	---	---
Dermal exposures				
At 25 feet	0.0001	++	++	++
At 100 feet	0.0001	++	++	++
Dog petting	0.0000	++	++	++

Table B-5--Margins of safety for workers
Nursery: Ashe
Pesticide: Napropamide

	Exposure (mg/kg/day)	Margin of safety relative to: LD_{50} (5000.0)	Systemic NOEL (25.00)	Reproductive NOEL (10.00)
Average				
Applicator	0.0068	++	++	++
Weeder	0.0002	++	++	++
Inventory	0.0013	++	++	++
Lifting	0.0000	++	++	++
Extreme				
Applicator	0.0151	++	++	660
Weeder	0.0221	++	++	450
Inventory	0.0221	++	++	450
Lifting	0.0000	++	++	++
Accident spray	0.2100	++	120	48
Accident spill	120.0000	42	-4.8	-12
Premature reentry	0.0846	++	300	120

Margins of Safety for Exposed Members of the Public

	Exposure (mg/kg/day)	Margin of safety relative to: LD_{50} (5000.0)	Systemic NOEL (25.00)	Reproductive NOEL (10.00)
Average over applications				
Dietary exposures				
Beef	0.0000	++	++	++
Rabbit	0.0009	++	++	++
Grouse	0.0007	++	++	++
Vegs., 25 feet	0.0023	++	++	++
Vegs., 100 feet	0.0016	++	++	++
Water, runoff	---	---	---	---
Water, drift	---	---	---	---
Dermal exposures				
At 25 feet	0.0007	++	++	++
At 100 feet	0.0005	++	++	++
Dog petting	0.0000	++	++	++
Lowest margins of safety				
Dietary exposures				
Beef	0.0000	++	++	++
Rabbit	0.0009	++	++	++
Grouse	0.0007	++	++	++
Vegs., 25 feet	0.0023	++	++	++
Vegs., 100 feet	0.0016	++	++	++
Water, runoff	---	---	---	---
Water, drift	---	---	---	---
Dermal exposures				
At 25 feet	0.0007	++	++	++
At 100 feet	0.0005	++	++	++
Dog petting	0.0000	++	++	++

Table B-6--Margins of safety for workers
Nursery: Ashe
Pesticide: Oxyfluorfen

	Exposure (mg/kg/day)	Margin of safety relative to: LD_{50} (5000.0)	Systemic NOEL (0.30)	Reproductive NOEL (0.50)
Average				
Applicator	0.0089	++	34	56
Weeder	0.0016	++	190	310
Inventory	0.0001	++	++	++
Lifting	0.0000	++	++	++
Extreme				
Applicator	0.0198	++	15	25
Weeder	0.0363	++	8.3	14
Inventory	0.0672	++	4.5	7.4
Lifting	0.0000	++	++	++
Accident spray	0.2100	++	1.4	2.4
Accident spill	120.0000	42	-400	-240
Premature reentry	0.0851	++	3.5	5.9

Margins of Safety for Exposed Members of the Public

	Exposure (mg/kg/day)	Margin of safety relative to: LD_{50} (5000.0)	Systemic NOEL (0.30)	Reproductive NOEL (0.50)
Average over applications				
Dietary exposures				
Beef	0.0000	++	++	++
Rabbit	0.0009	++	350	580
Grouse	0.0007	++	430	710
Vegs., 25 feet	0.0023	++	130	220
Vegs., 100 feet	0.0016	++	190	310
Water, runoff	---	---	---	---
Water, drift	---	---	---	---
Dermal exposures				
At 25 feet	0.0007	++	420	690
At 100 feet	0.0005	++	650	++
Dog petting	0.0000	++	++	++
Lowest margins of safety				
Dietary exposures				
Beef	0.0000	++	++	++
Rabbit	0.0009	++	350	580
Grouse	0.0007	++	430	710
Vegs., 25 feet	0.0023	++	130	220
Vegs., 100 feet	0.0016	++	190	310
Water, runoff	---	---	---	---
Water, drift	---	---	---	---
Dermal exposures				
At 25 feet	0.0007	++	420	690
At 100 feet	0.0005	++	650	++
Dog petting	0.0000	++	++	++

Table B-7--Margins of safety for workers
Nursery: Ashe
Pesticide: Sethoxydim

		Margin of safety relative to:		
	Exposure (mg/kg/day)	LD_{50} (2676.0)	Systemic NOEL (3.00)	Reproductive NOEL (160.00)
Average				
Applicator	0.0071	++	420	++
Weeder	0.0000	++	++	++
Inventory	0.0000	++	++	++
Lifting	0.0000	++	++	++
Extreme				
Applicator	0.0158	++	190	++
Weeder	0.0017	++	++	++
Inventory	0.0050	++	600	++
Lifting	0.0000	++	++	++
Accident spray	0.1700	++	18	940
Accident spill	92.0000	29	-31	1.7
Premature reentry	0.0659	++	46	++

Margins of Safety for Exposed Members of the Public

		Margin of safety relative to:		
	Exposure (mg/kg/day)	LD_{50} (2676.0)	Systemic NOEL (3.00)	Reproductive NOEL (160.00)
Average over applications				
Dietary exposures				
Beef	0.0000	++	++	++
Rabbit	0.0007	++	++	++
Grouse	0.0006	++	++	++
Vegs., 25 feet	0.0019	++	++	++
Vegs., 100 feet	0.0013	++	++	++
Water, runoff	---	---	---	---
Water, drift	---	---	---	---
Dermal exposures				
At 25 feet	0.0006	++	++	++
At 100 feet	0.0004	++	++	++
Dog petting	0.0000	++	++	++
Lowest margins of safety				
Dietary exposures				
Beef	0.0000	++	++	++
Rabbit	0.0007	++	++	++
Grouse	0.0006	++	++	++
Vegs., 25 feet	0.0019	++	++	++
Vegs., 100 feet	0.0013	++	++	++
Water, runoff	---	---	---	---
Water, drift	---	---	---	---
Dermal exposures				
At 25 feet	0.0006	++	++	++
At 100 feet	0.0004	++	++	++
Dog petting	0.0000	++	++	++

Table B-8--Margins of safety for workers
Nursery: Ashe
Pesticide: Simazine

	Exposure (mg/kg/day)	Margin of safety relative to: LD_{50} (5000.0)	Systemic NOEL (5.00)	Reproductive NOEL (5.00)
Average				
Applicator	0.0063	++	800	800
Weeder	0.0121	++	410	410
Inventory	---	---	---	---
Lifting	0.0000	++	++	++
Extreme				
Applicator	0.0140	++	360	360
Weeder	0.1685	++	30	30
Inventory	---	---	---	---
Lifting	---	---	---	---
Accident spray	0.8300	++	6.0	6.0
Accident spill	240.0000	21	-48	-48
Premature reentry	0.3412	++	15	15

Margins of Safety for Exposed Members of the Public

	Exposure (mg/kg/day)	Margin of safety relative to: LD_{50} (5000.0)	Systemic NOEL (5.00)	Reproductive NOEL (5.00)
Average over applications				
Dietary exposures				
Beef	0.0002	++	++	++
Rabbit	0.0034	++	++	++
Grouse	0.0028	++	++	++
Vegs., 25 feet	0.0094	++	530	530
Vegs., 100 feet	0.0064	++	780	780
Water, runoff	---	---	---	---
Water, drift	---	---	---	---
Dermal exposures				
At 25 feet	0.0029	++	++	++
At 100 feet	0.0018	++	++	++
Dog petting	0.0002	++	++	++
Lowest margins of safety				
Dietary exposures				
Beef	0.0002	++	++	++
Rabbit	0.0034	++	++	++
Grouse	0.0028	++	++	++
Vegs., 25 feet	0.0094	++	530	530
Vegs., 100 feet	0.0064	++	780	780
Water, runoff	---	---	---	---
Water, drift	---	---	---	---
Dermal exposures				
At 25 feet	0.0029	++	++	++
At 100 feet	0.0018	++	++	++
Dog petting	0.0002	++	++	++

Table B-9--Margins of safety for workers
Nursery: Ashe
Pesticide: Benomyl

	Exposure (mg/kg/day)	Margin of safety relative to: LD_{50} (10000.0)	Systemic NOEL (12.50)	Reproductive NOEL (5.00)
Average				
Applicator	0.0089	++	++	560
Weeder	0.0355	++	350	140
Inventory	0.0055	++	++	920
Lifting	0.0000	++	++	++
Extreme				
Applicator	0.0198	++	630	250
Weeder	0.0725	++	170	69
Inventory	0.0725	++	170	69
Lifting	0.0023	++	++	++
Accident spray	0.2100	++	60	24
Accident spill	---	---	---	---
Premature reentry	0.0854	++	150	59

Margins of Safety for Exposed Members of the Public

	Exposure (mg/kg/day)	Margin of safety relative to: LD_{50} (10000.0)	Systemic NOEL (12.50)	Reproductive NOEL (5.00)
Average over applications				
Dietary exposures				
Beef	0.0000	++	++	++
Rabbit	0.0009	++	++	++
Grouse	0.0007	++	++	++
Vegs., 25 feet	0.0023	++	++	++
Vegs., 100 feet	0.0016	++	++	++
Water, runoff	---	---	---	---
Water, drift	---	---	---	---
Dermal exposures				
At 25 feet	0.0007	++	++	++
At 100 feet	0.0005	++	++	++
Dog petting	0.0000	++	++	++
Lowest margins of safety				
Dietary exposures				
Beef	0.0000	++	++	++
Rabbit	0.0009	++	++	++
Grouse	0.0007	++	++	++
Vegs., 25 feet	0.0023	++	++	++
Vegs., 100 feet	0.0016	++	++	++
Water, runoff	---	---	---	---
Water, drift	---	---	---	---
Dermal exposures				
At 25 feet	0.0007	++	++	++
At 100 feet	0.0005	++	++	++
Dog petting	0.0000	++	++	++

Table B-10--Margins of safety for workers
Nursery: Ashe
Pesticide: Captan

	Exposure (mg/kg/day)	Margin of safety relative to: LD_{50} (9000.0)	Systemic NOEL (25.00)	Reproductive NOEL (12.50)
Average				
Applicator	0.0267	++	940	470
Weeder	0.0854	++	290	150
Inventory	0.0166	++	++	750
Lifting	0.0000	++	++	++
Extreme				
Applicator	0.0593	++	420	210
Weeder	0.2043	++	120	61
Inventory	0.1139	++	220	110
Lifting	0.0000	++	++	++
Accident spray	0.6300	++	40	20
Accident spill	240.0000	38	-9.6	-19
Premature reentry	0.2555	++	98	49

Margins of Safety for Exposed Members of the Public

	Exposure (mg/kg/day)	Margin of safety relative to: LD_{50} (9000.0)	Systemic NOEL (25.00)	Reproductive NOEL (12.50)
Average over applications				
Dietary exposures				
Beef	0.0001	++	++	++
Rabbit	0.0026	++	++	++
Grouse	0.0021	++	++	++
Vegs., 25 feet	0.0070	++	++	++
Vegs., 100 feet	0.0048	++	++	++
Water, runoff	---	---	---	---
Water, drift	---	---	---	---
Dermal exposures				
At 25 feet	0.0022	++	++	++
At 100 feet	0.0014	++	++	++
Dog petting	0.0001	++	++	++
Lowest margins of safety				
Dietary exposures				
Beef	0.0001	++	++	++
Rabbit	0.0026	++	++	++
Grouse	0.0021	++	++	++
Vegs., 25 feet	0.0070	++	++	++
Vegs., 100 feet	0.0048	++	++	++
Water, runoff	---	---	---	---
Water, drift	---	---	---	---
Dermal exposures				
At 25 feet	0.0022	++	++	++
At 100 feet	0.0014	++	++	++
Dog petting	0.0001	++	++	++

Table B-11--Margins of safety for workers
Nursery: Ashe
Pesticide: Chlorothalonil

	Exposure (mg/kg/day)	Margin of safety relative to: LD_{50} (10000.0)	Systemic NOEL (1.50)	Reproductive NOEL (5.00)
Average				
Applicator	0.0267	++	56	190
Weeder	0.1056	++	14	47
Inventory	0.0288	++	52	170
Lifting	0.0014	++	1000	++
Extreme				
Applicator	0.0593	++	25	84
Weeder	0.2170	++	6.9	23
Inventory	0.1407	++	11	36
Lifting	0.0880	++	17	57
Accident spray	0.6300	++	2.4	7.9
Accident spill	360.0000	28	-240	-72
Premature reentry	0.2562	++	5.9	20

Margins of Safety for Exposed Members of the Public

	Exposure (mg/kg/day)	Margin of safety relative to: LD_{50} (10000.0)	Systemic NOEL (1.50)	Reproductive NOEL (5.00)
Average over applications				
Dietary exposures				
Beef	0.0001	++	++	++
Rabbit	0.0026	++	580	++
Grouse	0.0021	++	710	++
Vegs., 25 feet	0.0070	++	210	710
Vegs., 100 feet	0.0048	++	310	1000
Water, runoff	---	---	---	---
Water, drift	---	---	---	---
Dermal exposures				
At 25 feet	0.0022	++	680	++
At 100 feet	0.0014	++	++	++
Dog petting	0.0001	++	++	++
Lowest margins of safety				
Dietary exposures				
Beef	0.0001	++	++	++
Rabbit	0.0026	++	580	++
Grouse	0.0021	++	710	++
Vegs., 25 feet	0.0070	++	210	710
Vegs., 100 feet	0.0048	++	310	1000
Water, runoff	---	---	---	---
Water, drift	---	---	---	---
Dermal exposures				
At 25 feet	0.0022	++	680	++
At 100 feet	0.0014	++	++	++
Dog petting	0.0001	++	++	++

Table B-12--Margins of safety for workers
Nursery: Ashe
Pesticide: Triadimefon

		Margin of safety relative to:		
	Exposure (mg/kg/day)	LD_{50} (363.0)	Systemic NOEL (2.50)	Reproductive NOEL (2.50)
Average				
Applicator	0.0052	++	480	480
Weeder	0.0368	++	68	68
Inventory	0.0074	++	340	340
Lifting	0.0000	++	++	++
Extreme				
Applicator	0.0116	++	220	220
Weeder	0.0733	++	34	34
Inventory	0.0174	++	140	140
Lifting	0.0000	++	++	++
Accident spray	0.2100	++	12	12
Accident spill	---	---	---	---
Premature reentry	0.0854	++	29	29

Margins of Safety for Exposed Members of the Public

		Margin of safety relative to:		
	Exposure (mg/kg/day)	LD_{50} (363.0)	Systemic NOEL (2.50)	Reproductive NOEL (2.50)
Average over applications				
Dietary exposures				
Beef	0.0000	++	++	++
Rabbit	0.0009	++	++	++
Grouse	0.0007	++	++	++
Vegs., 25 feet	0.0023	++	++	++
Vegs., 100 feet	0.0016	++	++	++
Water, runoff	---	---	---	---
Water, drift	---	---	---	---
Dermal exposures				
At 25 feet	0.0007	++	++	++
At 100 feet	0.0005	++	++	++
Dog petting	0.0000	++	++	++
Lowest margins of safety				
Dietary exposures				
Beef	0.0000	++	++	++
Rabbit	0.0009	++	++	++
Grouse	0.0007	++	++	++
Vegs., 25 feet	0.0023	++	++	++
Vegs., 100 feet	0.0016	++	++	++
Water, runoff	---	---	---	---
Water, drift	---	---	---	---
Dermal exposures				
At 25 feet	0.0007	++	++	++
At 100 feet	0.0005	++	++	++
Dog petting	0.0000	++	++	++

Table B-13--Margins of safety for workers
Nursery: Ashe
Pesticide: Diazinon

	Exposure (mg/kg/day)	Margin of safety relative to: LD_{50} (250.0)	Systemic NOEL (0.02)	Reproductive NOEL (0.20)
Average				
Applicator	0.0089	++	2.3	23
Weeder	0.0157	++	1.3	13
Inventory	0.0000	++	1000	++
Lifting	0.0000	++	++	++
Extreme				
Applicator	0.0198	++	1.0	10
Weeder	0.0574	++	-2.9	3.5
Inventory	0.0015	++	13	130
Lifting	0.0000	++	++	++
Accident spray	0.2100	++	-11	-1.0
Accident spill	360.0000	-1.4	-18000	-1800
Premature reentry	0.0846	++	-4.2	2.4

Margins of Safety for Exposed Members of the Public

	Exposure (mg/kg/day)	Margin of safety relative to: LD_{50} (250.0)	Systemic NOEL (0.02)	Reproductive NOEL (0.20)
Average over applications				
Dietary exposures				
Beef	0.0000	++	650	++
Rabbit	0.0009	++	23	230
Grouse	0.0007	++	29	290
Vegs., 25 feet	0.0023	++	8.7	87
Vegs., 100 feet	0.0016	++	13	130
Water, runoff	---	---	---	---
Water, drift	---	---	---	---
Dermal exposures				
At 25 feet	0.0007	++	28	280
At 100 feet	0.0005	++	43	430
Dog petting	0.0000	++	430	++
Lowest margins of safety				
Dietary exposures				
Beef	0.0000	++	650	++
Rabbit	0.0009	++	23	230
Grouse	0.0007	++	29	290
Vegs., 25 feet	0.0023	++	8.7	87
Vegs., 100 feet	0.0016	++	13	130
Water, runoff	---	---	---	---
Water, drift	---	---	---	---
Dermal exposures				
At 25 feet	0.0007	++	28	280
At 100 feet	0.0005	++	43	430
Dog petting	0.0000	++	430	++

Table B-14--Lifetime cancer risk for exposed members of the public
Nursery: Ashe

	Atrazine	Oxyfluorfen	Glyphosate	Chlorothalonil	Benomyl	Captan
5 Exposures						
Rabbit	1.E-07	5.E-12	8.E-13	1.E-08	1.E-09	3.E-09
Vegs. (25 ft)	3.E-07	1.E-11	2.E-12	3.E-08	3.E-09	7.E-09
Water, drift	----	----	----	----	----	----
Dermal (25 ft)	1.E-07	4.E-12	7.E-13	1.E-08	9.E-10	2.E-09
30 Exposures						
Rabbit	7.E-07	3.E-11	5.E-12	7.E-08	7.E-09	2.E-08
Vegs. (25 ft)	2.E-06	8.E-11	1.E-11	2.E-07	2.E-08	4.E-08
Water, drift	----	----	----	----	----	----
Dermal (25 ft)	6.E-07	2.E-11	4.E-12	6.E-08	6.E-09	1.E-08

Table B-15--Lifetime cancer risk for workers
Nursery: Ashe

	Atrazine	Oxyfluorfen	Glyphosate	Chlorothalonil	Benomyl	Captan
5 Years of exposure						
Weeding	----	2.E-09	4.E-10	9.E-05	9.E-06	2.E-05
Inventory	----	6.E-11	9.E-10	1.E-05	6.E-07	1.E-06
Lifting	----	2.E-13	1.E-12	9.E-07	7.E-09	3.E-11
Application	1.E-06	4.E-10	1.E-11	4.E-07	1.E-07	4.E-08
30 Years of exposure						
Weeding	----	1.E-08	2.E-09	5.E-04	5.E-05	1.E-04
Inventory	----	4.E-10	5.E-09	6.E-05	3.E-06	8.E-06
Lifting	----	1.E-12	8.E-12	6.E-06	4.E-08	2.E-10
Application	7.E-06	3.E-09	7.E-11	2.E-06	7.E-07	2.E-07

C. Bend Pine Nursery

EXPOSURE ANALYSIS METHODS

The Bend Pine Nursery, located in Oregon, has a total area of 213 acres and a total nursery bed area of 65 acres. Approximately 60 acres are treated with pesticides every year. The nursery generally employs the following number of personnel annually for its operations: 2 mixer/loader/applicators, 11 to 24 weeders, 10 to 12 inventory personnel, 24 to 35 lifters, 65 to 68 sorters and packers, 1 to 4 fumigators, 3 to 6 tarp lifters, 5 tractor operators, and 2 irrigators.

The exposure analysis methods used to estimate doses to workers and the public in the Bend Pine Nursery were similar to those described for the generic nursery, except that the conditions specific to the nursery, such as the pesticides used, the application rates, and the timing of the applications, were used in the analyses rather than the generic set of conditions. The pesticide application schedule for the nursery is shown in table C-1. (Tables can be found at the end of this section.) For the purposes of determining foliar washoff of pesticide residues, each bed was assumed to be irrigated every other day at a rate of 0.5 inches per day. Methyl bromide and chloropicrin are applied to approximately 20 acres in August.

There are no Forest Service residences onsite and none within 100 feet of the nursery boundary. There are four residences within 200 feet of the nursery boundary. The land bordering the nursery is farmland and rangeland.

The nearest live water is an irrigation ditch approximately 175 feet from the nursery boundary. It is used for both irrigation and domestic purposes. The ditch shoulders are raised above the nursery beds, and the water surface is at or above the surface of the beds. An aquifer is located at a depth of 750 feet. The soil is predominantly loamy sand or sand.

RISK ANALYSIS

Risk of Systemic and Reproductive Effects

Risks to members of the public and workers involved in pesticide applications and related nursery tasks in the Bend Pine Nursery are based on the methods described in chapters 3 and 4 of the generic nursery risk assessment. Tables C-2 to C-5 present exposure levels and margins of safety for the pesticides used in the Bend Pine Nursery, based on LD_{50}'s, systemic NOEL's, and reproductive NOEL's for routine-realistic (average), routine-extreme, and accidental exposures.

The MOS tables for each chemical consist of two parts. The first lists worker exposures and MOS's for the chemical as it is used in the Bend Pine Nursery. The worker portion lists MOS's for routine-realistic (average), routine-extreme (extreme), and accidental exposures (spraying,

spills on the skin, and premature reentry). LD_{50}'s and NOEL's are listed above each column of MOS's.

The second portion of each table lists public exposures and MOS's via specific exposure routes for routine-realistic (average) and routine-extreme (lowest MOS's) exposures. The only accidents that may affect the public are assumed to be those involving fumigant spills. The analysis of fumigant spills is contained in the generic nursery risk analysis.

Dashes in the worker portion of the tables indicate that the chemical is used only in cover crops. Dashes in the public portion indicate that the route of exposure is not considered a significant one in this analysis. Margins of safety greater than 1,000 are indicated by ++.

Where MOS's are greater than 100, risk can be considered negligible for the chemical in question. MOS's between 10 and 100 indicate a slight risk of low-level toxic effects--to sensitive individuals in particular. MOS's between 1 and 10 indicate a moderate risk of low-level toxic effects, especially in light of the uncertainty in extrapolating from laboratory test animal species to humans. Risk may be significant where an MOS for a chemical is negative (the estimated exposure exceeds the animal NOEL). Refer to the discussion of low-level toxic effects in the generic nursery risk analysis.

Cancer Risk

The cancer risk for members of the public potentially exposed to oxyfluorfen at the Bend Pine Nursery is presented in table C-6. Worker cancer risk is given in table C-7. The greatest public risk is less than 1 in 100 billion. The greatest risk to workers is 2 in 1 billion.

Table C-1--Bend Pine Nursery schedule for pesticide applications (based on average use)

Crop	Year	Chemical	Acres	Rate (lb/acre)	Applications per year	Month of application
Cover Crop	0	Glyphosate	20	0.5	1	Mar, Apr
Pine	1	Metalaxyl	7	4.6	1	Jun
Pine	1	Bifenox	20	3.0	2	Apr, Aug
Pine	2	Metalaxyl	7	4.6	1	Jun
Pine	2	Bifenox	20	3.0	2	May, Aug
Pine	2	Oxyfluorfen	20	0.5	2	Jun, Sep

Table C-2--Margins of safety for workers
Nursery: Bend Pine
Pesticide: Bifenox

	Exposure (mg/kg/day)	Margin of safety relative to: LD_{50} (6400.0)	Systemic NOEL (12.50)	Reproductive NOEL (10.00)
Average				
Applicator	0.0125	++	1000	800
Weeder	0.0039	++	++	++
Inventory	0.0097	++	++	1000
Lifting	0.0000	++	++	++
Extreme				
Applicator	0.0279	++	450	360
Weeder	0.1762	++	71	57
Inventory	0.3797	++	33	26
Lifting	0.0000	++	++	++
Accident spray	1.3000	++	9.6	7.7
Accident spill	120.0000	53	-9.6	-12
Premature reentry	0.5095	++	25	20

Margins of Safety for Exposed Members of the Public

	Exposure (mg/kg/day)	Margin of safety relative to: LD_{50} (6400.0)	Systemic NOEL (12.50)	Reproductive NOEL (10.00)
Average over applications				
Dietary exposures				
Beef	0.0002	++	++	++
Rabbit	0.0052	++	++	++
Grouse	0.0042	++	++	++
Vegs., 25 feet	0.0140	++	890	710
Vegs., 100 feet	0.0097	++	++	1000
Water, runoff	---	---	---	---
Water, drift	---	---	---	---
Dermal exposures				
At 25 feet	0.0043	++	++	++
At 100 feet	0.0028	++	++	++
Dog petting	0.0003	++	++	++
Lowest margins of safety				
Dietary exposures				
Beef	0.0002	++	++	++
Rabbit	0.0052	++	++	++
Grouse	0.0042	++	++	++
Vegs., 25 feet	0.0140	++	890	710
Vegs., 100 feet	0.0097	++	++	1000
Water, runoff	---	---	---	---
Water, drift	---	---	---	---
Dermal exposures				
At 25 feet	0.0043	++	++	++
At 100 feet	0.0028	++	++	++
Dog petting	0.0003	++	++	++

Table C-3--Margins of safety for workers
Nursery: Bend Pine
Pesticide: Glyphosate

		Margin of safety relative to:		
	Exposure (mg/kg/day)	LD_{50} (4320.0)	Systemic NOEL (30.00)	Reproductive NOEL (10.00)
Average				
Applicator	0.0021	++	++	++
Weeder	---	---	---	---
Inventory	---	---	---	---
Lifting	---	---	---	---
Extreme				
Applicator	0.0047	++	++	++
Weeder	---	---	---	---
Inventory	---	---	---	---
Lifting	---	---	---	---
Accident spray	0.2100	++	140	48
Accident spill	180.0000	24	-6.0	-18
Premature reentry	---	---	---	---

Margins of Safety for Exposed Members of the Public

		Margin of safety relative to:		
	Exposure (mg/kg/day)	LD_{50} (4320.0)	Systemic NOEL (30.00)	Reproductive NOEL (10.00)
Average over applications				
Dietary exposures				
Beef	0.0000	++	++	++
Rabbit	0.0009	++	++	++
Grouse	0.0007	++	++	++
Vegs., 25 feet	0.0023	++	++	++
Vegs., 100 feet	0.0016	++	++	++
Water, runoff	---	---	---	---
Water, drift	---	---	---	---
Dermal exposures				
At 25 feet	0.0007	++	++	++
At 100 feet	0.0005	++	++	++
Dog petting	0.0000	++	++	++
Lowest margins of safety				
Dietary exposures				
Beef	0.0000	++	++	++
Rabbit	0.0009	++	++	++
Grouse	0.0007	++	++	++
Vegs., 25 feet	0.0023	++	++	++
Vegs., 100 feet	0.0016	++	++	++
Water, runoff	---	---	---	---
Water, drift	---	---	---	---
Dermal exposures				
At 25 feet	0.0007	++	++	++
At 100 feet	0.0005	++	++	++
Dog petting	0.0000	++	++	++

Table C-4--Margins of safety for workers
Nursery: Bend Pine
Pesticide: Oxyfluorfen

	Exposure (mg/kg/day)	Margin of safety relative to: LD_{50} (5000.0)	Systemic NOEL (0.30)	Reproductive NOEL (0.50)
Average				
Applicator	0.0021	++	140	240
Weeder	0.0016	++	190	310
Inventory	0.0001	++	++	++
Lifting	0.0000	++	++	++
Extreme				
Applicator	0.0047	++	65	110
Weeder	0.0363	++	8.3	14
Inventory	0.0672	++	4.5	7.4
Lifting	0.0000	++	++	++
Accident spray	0.2100	++	1.4	2.4
Accident spill	120.0000	42	-400	-240
Premature reentry	0.0851	++	3.5	5.9

Margins of Safety for Exposed Members of the Public

	Exposure (mg/kg/day)	Margin of safety relative to: LD_{50} (5000.0)	Systemic NOEL (0.30)	Reproductive NOEL (0.50)
Average over applications				
Dietary exposures				
Beef	0.0000	++	++	++
Rabbit	0.0009	++	350	580
Grouse	0.0007	++	430	710
Vegs., 25 feet	0.0023	++	130	220
Vegs., 100 feet	0.0016	++	190	310
Water, runoff	---	---	---	---
Water, drift	---	---	---	---
Dermal exposures				
At 25 feet	0.0007	++	420	690
At 100 feet	0.0005	++	650	++
Dog petting	0.0000	++	++	++
Lowest margins of safety				
Dietary exposures				
Beef	0.0000	++	++	++
Rabbit	0.0009	++	350	580
Grouse	0.0007	++	430	710
Vegs., 25 feet	0.0023	++	130	220
Vegs., 100 feet	0.0016	++	190	310
Water, runoff	---	---	---	---
Water, drift	---	---	---	---
Dermal exposures				
At 25 feet	0.0007	++	420	690
At 100 feet	0.0005	++	650	++
Dog petting	0.0000	++	++	++

Table C-5--Margins of safety for workers
Nursery: Bend Pine
Pesticide: Metalaxyl

		Margin of safety relative to:		
	Exposure (mg/kg/day)	LD_{50} (669.0)	Systemic NOEL (6.25)	Reproductive NOEL (50.00)
Average				
Applicator	0.0067	++	930	++
Weeder	0.1903	++	33	260
Inventory	0.0196	++	320	++
Lifting	0.0000	++	++	++
Extreme				
Applicator	0.0150	++	420	++
Weeder	0.5717	++	11	87
Inventory	0.5717	++	11	87
Lifting	0.0001	++	++	++
Accident spray	1.9000	350	3.3	26
Accident spill	120.0000	5.6	-19	-2.4
Premature reentry	0.7807	860	8.0	64

Margins of Safety for Exposed Members of the Public

		Margin of safety relative to:		
	Exposure (mg/kg/day)	LD_{50} (669.0)	Systemic NOEL (6.25)	Reproductive NOEL (50.00)
Average over applications				
Dietary exposures				
Beef	0.0003	++	++	++
Rabbit	0.0079	++	790	++
Grouse	0.0064	++	980	++
Vegs., 25 feet	0.0220	++	280	++
Vegs., 100 feet	0.0150	++	420	++
Water, runoff	---	---	---	---
Water, drift	---	---	---	---
Dermal exposures				
At 25 feet	0.0067	++	930	++
At 100 feet	0.0042	++	++	++
Dog petting	0.0004	++	++	++
Lowest margins of safety				
Dietary exposures				
Beef	0.0003	++	++	++
Rabbit	0.0079	++	790	++
Grouse	0.0064	++	980	++
Vegs., 25 feet	0.0220	++	280	++
Vegs., 100 feet	0.0150	++	420	++
Water, runoff	---	---	---	---
Water, drift	---	---	---	---
Dermal exposures				
At 25 feet	0.0067	++	930	++
At 100 feet	0.0042	++	++	++
Dog petting	0.0004	++	++	++

Table C-6--Lifetime cancer risk for exposed members of the public
Nursery: Bend Pine

	Oxyfluorfen	Glyphosate
5 Exposures		
Rabbit	5.E-12	4.E-12
Vegs. (25 ft)	1.E-11	1.E-11
Water, drift	----	----
Dermal (25 ft)	4.E-12	3.E-12
30 Exposures		
Rabbit	3.E-11	2.E-11
Vegs. (25 ft)	8.E-11	6.E-11
Water, drift	----	----
Dermal (25 ft)	2.E-11	2.E-11

Table C-7--Lifetime cancer risk for workers
Nursery: Bend Pine

	Oxyfluorfen	Glyphosate
5 Years of exposure		
Weeding	3.E-10	----
Inventory	1.E-11	----
Lifting	3.E-14	----
Application	8.E-12	3.E-12
30 Years of exposure		
Weeding	2.E-09	----
Inventory	6.E-11	----
Lifting	2.E-13	----
Application	5.E-11	2.E-11

D. Bessey Nursery

EXPOSURE ANALYSIS METHODS

The Bessey Nursery, located in Nebraska, has a total area of 75 acres and a total nursery bed area of 46 acres. All 46 bed-acres are treated with pesticides every year. The nursery generally employs the following number of personnel annually for its operations: 2 to 4 mixer/loader/applicators, 11 to 24 weeders, 6 to 8 inventory personnel, 15 to 30 lifters, 40 to 50 sorters and packers, 4 fumigators, and 2 tarp lifters.

The exposure analysis methods used to estimate doses to workers and the public in the Bessey Nursery were similar to those described for the generic nursery, except that the conditions specific to the nursery, such as the pesticides used, the application rates, and the timing of the applications, were used in the analyses rather than the generic set of conditions. The pesticide application schedule for the nursery is given in table D-1. (Tables can be found at the end of this section.) For the purposes of determining foliar washoff of pesticide residues, each bed was assumed to be irrigated every other day at a rate of 0.25 inches per day. Methyl bromide and chloropicrin are applied to approximately 7.6 acres in April or July.

There are six Forest Service residences onsite; three of these are within 100 feet of the nursery beds. The land bordering the nursery includes residential land, forest, farmland, and rangeland.

The nearest live water is a river approximately 100 feet from the nursery boundary. There is an aquifer 10 to 15 feet below the nursery. The Bessey Nursery has sandy soil.

RISK ANALYSIS

Risk of Systemic and Reproductive Effects

Risks to members of the public and workers involved in pesticide applications and related nursery tasks in the Bessey Nursery are based on the methods described in chapters 3 and 4 of the generic nursery risk assessment. Tables D-2 through D-9 present exposure levels and margins of safety based on LD_{50}'s, systemic NOEL's, and reproductive NOEL's for routine-realistic (average), routine-extreme, and accidental exposures.

The MOS tables for each chemical consist of two parts. The first lists worker exposures and MOS's for the chemical as it is used in the Bessey Nursery. The worker portion lists MOS's for routine-realistic (average), routine-extreme (extreme), and accidental exposures (spraying, spills on the skin, and premature reentry). LD_{50}'s and NOEL's are listed above each column of MOS's.

The second portion of each table lists public exposures and MOS's via specific exposure routes for routine-realistic (average) and routine-extreme (lowest MOS's) exposures. The only accidents that may affect the public are assumed to be those involving fumigant spills. The analysis of fumigant spills is contained in the generic nursery risk analysis.

Dashes in the worker portion of the tables indicate that the chemical is used only in cover crops. Dashes in the public portion indicate that the route of exposure is not considered a significant one in this analysis. Margins of safety greater than 1,000 are indicated by ++.

Where MOS's are greater than 100, risk can be considered negligible for the chemical in question. MOS's between 10 and 100 indicate a slight risk of low-level toxic effects--to sensitive individuals in particular. MOS's between 1 and 10 indicate moderate risk of low-level toxic effects, especially in light of the uncertainty in extrapolating from laboratory test animal species to humans. Risk may be significant where an MOS for a chemical is negative (the estimated exposure exceeds the animal NOEL). Refer to the discussion of low-level toxic effects in the generic nursery risk analysis.

Cancer Risk

Lifetime cancer risks for the known or suspected carcinogenic chemicals oxyfluorfen, glyphosate, chlorothalonil, benomyl, dimethoate, and carbaryl to members of the public at the Bessey Nursery are listed in table D-10 for different exposure routes and numbers of lifetime exposures. Lifetime cancer risk to workers from the use of those chemicals in various nursery tasks are listed in table D-11. The cancer risk tables should be interpreted as follows. Where the exponent is lower, the risk is higher. For example, a risk value of 1.0E-06 (1 chance in 1 million) is lower than a risk of 1.0E-05 (1 chance in 100,000). A risk of 7.0E-06 exceeds a risk of 1.0E-06.

In general, risk may be considered acceptable where risk to an individual is equal to or lower than 1 in 1 million. Where risk exceeds 1 chance in 100,000, proper precautions that reduce exposure levels may, in turn, reduce the cancer risk to acceptable levels.

Table D-1--Bessey Nursery schedule for pesticide applications (based on average use)

Crop	Year	Chemical	Acres	Rate (lb/acre)	Applications per year	Month of application
Cover crop	0	Glyphosate	2.0	0.4	3	Jun-Aug
Pine	1	DCPA or napropamide	4.3	5.25/1.5	2	Jul
Other conifers	1	DCPA	5.3	5.25	1	Jul
Hardwoods	1	DCPA	2.3	5.25	2	May-Jun
Hardwoods	1	Carbaryl	0.8	0.8	2	Jun-Aug
Pine	2	Chlorothalonil	8.0	1.4	3	Aug-Sep
Pine	2	Oxyfluorfen	2.0	0.25	1	Aug
Pine	2	Dimethoate	4.3	0.5	6	May-Jul
Pine	2	DCPA or napropamide	4.3	5.25/1.5	2	Jun, Jul
Other conifers	2	DCPA or napropamide	5.3	5.25/1.5	2	Jun, Jul
Other conifers	2	Benomyl	5.3	0.5	7	Jun-Sep

Table D-2--Margins of safety for workers
Nursery: Bessey
Pesticide: DCPA

	Exposure (mg/kg/day)	Margin of safety relative to: LD_{50} (10250.0)	Systemic NOEL (50.00)	Reproductive NOEL (50.00)
Average				
Applicator	0.0049	++	++	++
Weeder	0.1243	++	400	400
Inventory	0.0937	++	530	530
Lifting	0.0010	++	++	++
Extreme				
Applicator	0.0129	++	++	++
Weeder	0.6081	++	82	82
Inventory	0.6081	++	82	82
Lifting	0.0013	++	++	++
Accident spray	2.2000	++	23	23
Accident spill	360.0000	28	-7.2	-7.2
Premature reentry	0.8989	++	56	56

Margins of Safety for Exposed Members of the Public

	Exposure (mg/kg/day)	Margin of safety relative to: LD_{50} (10250.0)	Systemic NOEL (50.00)	Reproductive NOEL (50.00)
Average over applications				
Dietary exposures				
Beef	0.0004	++	++	++
Rabbit	0.0090	++	++	++
Grouse	0.0074	++	++	++
Vegs., 25 feet	0.0250	++	++	++
Vegs., 100 feet	0.0170	++	++	++
Water, runoff	---	---	---	---
Water, drift	0.0000	++	++	++
Dermal exposures				
At 25 feet	0.0076	++	++	++
At 100 feet	0.0048	++	++	++
Dog petting	0.0005	++	++	++
Lowest margins of safety				
Dietary exposures				
Beef	0.0004	++	++	++
Rabbit	0.0090	++	++	++
Grouse	0.0074	++	++	++
Vegs., 25 feet	0.0250	++	++	++
Vegs., 100 feet	0.0170	++	++	++
Water, runoff	---	---	---	---
Water, drift	0.0000	++	++	++
Dermal exposures				
At 25 feet	0.0076	++	++	++
At 100 feet	0.0048	++	++	++
Dog petting	0.0005	++	++	++

Table D-3--Margins of safety for workers
Nursery: Bessey
Pesticide: Glyphosate

		Margin of safety relative to:		
	Exposure (mg/kg/day)	LD_{50} (4320.0)	Systemic NOEL (30.00)	Reproductive NOEL (10.00)
Average				
Applicator	0.0002	++	++	++
Weeder	---	---	---	---
Inventory	---	---	---	---
Lifting	---	---	---	---
Extreme				
Applicator	0.0004	++	++	++
Weeder	---	---	---	---
Inventory	---	---	---	---
Lifting	---	---	---	---
Accident spray	0.1700	++	180	59
Accident spill	180.0000	24	-6.0	-18
Premature reentry	---	---	---	---

Margins of Safety for Exposed Members of the Public

		Margin of safety relative to:		
	Exposure (mg/kg/day)	LD_{50} (4320.0)	Systemic NOEL (30.00)	Reproductive NOEL (10.00)
Average over applications				
Dietary exposures				
Beef	0.0000	++	++	++
Rabbit	0.0007	++	++	++
Grouse	0.0006	++	++	++
Vegs., 25 feet	0.0019	++	++	++
Vegs., 100 feet	0.0013	++	++	++
Water, runoff	---	---	---	---
Water, drift	0.0001	++	++	++
Dermal exposures				
At 25 feet	0.0006	++	++	++
At 100 feet	0.0004	++	++	++
Dog petting	0.0000	++	++	++
Lowest margins of safety				
Dietary exposures				
Beef	0.0000	++	++	++
Rabbit	0.0007	++	++	++
Grouse	0.0006	++	++	++
Vegs., 25 feet	0.0019	++	++	++
Vegs., 100 feet	0.0013	++	++	++
Water, runoff	---	---	---	---
Water, drift	0.0001	++	++	++
Dermal exposures				
At 25 feet	0.0006	++	++	++
At 100 feet	0.0004	++	++	++
Dog petting	0.0000	++	++	++

Table D-4--Margins of safety for workers
Nursery: Bessey
Pesticide: Napropamide

		Margin of safety relative to:		
	Exposure (mg/kg/day)	LD_{50} (5000.0)	Systemic NOEL (25.00)	Reproductive NOEL (10.00)
Average				
Applicator	0.0015	++	++	++
Weeder	0.0015	++	++	++
Inventory	0.0075	++	++	++
Lifting	0.0000	++	++	++
Extreme				
Applicator	0.0037	++	++	++
Weeder	0.0827	++	300	120
Inventory	0.0827	++	300	120
Lifting	0.0000	++	++	++
Accident spray	0.6300	++	40	16
Accident spill	120.0000	42	-4.8	-12
Premature reentry	0.2546	++	98	39

Margins of Safety for Exposed Members of the Public

		Margin of safety relative to:		
	Exposure (mg/kg/day)	LD_{50} (5000.0)	Systemic NOEL (25.00)	Reproductive NOEL (10.00)
Average over applications				
Dietary exposures				
Beef	0.0001	++	++	++
Rabbit	0.0026	++	++	++
Grouse	0.0021	++	++	++
Vegs., 25 feet	0.0070	++	++	++
Vegs., 100 feet	0.0048	++	++	++
Water, runoff	---	---	---	---
Water, drift	0.0000	++	++	++
Dermal exposures				
At 25 feet	0.0022	++	++	++
At 100 feet	0.0014	++	++	++
Dog petting	0.0001	++	++	++
Lowest margins of safety				
Dietary exposures				
Beef	0.0001	++	++	++
Rabbit	0.0026	++	++	++
Grouse	0.0021	++	++	++
Vegs., 25 feet	0.0070	++	++	++
Vegs., 100 feet	0.0048	++	++	++
Water, runoff	---	---	---	---
Water, drift	0.0000	++	++	++
Dermal exposures				
At 25 feet	0.0022	++	++	++
At 100 feet	0.0014	++	++	++
Dog petting	0.0001	++	++	++

Table D-5--Margins of safety for workers
Nursery: Bessey
Pesticide: Oxyfluorfen

		Margin of safety relative to:		
	Exposure (mg/kg/day)	LD_{50} (5000.0)	Systemic NOEL (0.30)	Reproductive NOEL (0.50)
Average				
Applicator	0.0001	++	++	++
Weeder	0.0021	++	140	240
Inventory	0.0003	++	900	++
Lifting	0.0000	++	++	++
Extreme				
Applicator	0.0002	++	++	++
Weeder	0.0227	++	13	22
Inventory	0.0358	++	8.4	14
Lifting	0.0000	++	++	++
Accident spray	0.1000	++	3.0	5.0
Accident spill	120.0000	42	-400	-240
Premature reentry	0.0427	++	7.0	12

Margins of Safety for Exposed Members of the Public

		Margin of safety relative to:		
	Exposure (mg/kg/day)	LD_{50} (5000.0)	Systemic NOEL (0.30)	Reproductive NOEL (0.50)
Average over applications				
Dietary exposures				
Beef	0.0000	++	++	++
Rabbit	0.0004	++	700	++
Grouse	0.0003	++	860	++
Vegs., 25 feet	0.0012	++	250	420
Vegs., 100 feet	0.0008	++	370	620
Water, runoff	---	---	---	---
Water, drift	0.0001	++	++	++
Dermal exposures				
At 25 feet	0.0004	++	830	++
At 100 feet	0.0002	++	++	++
Dog petting	0.0000	++	++	++
Lowest margins of safety				
Dietary exposures				
Beef	0.0000	++	++	++
Rabbit	0.0004	++	700	++
Grouse	0.0003	++	860	++
Vegs., 25 feet	0.0012	++	250	420
Vegs., 100 feet	0.0008	++	370	620
Water, runoff	---	---	---	---
Water, drift	0.0001	++	++	++
Dermal exposures				
At 25 feet	0.0004	++	830	++
At 100 feet	0.0002	++	++	++
Dog petting	0.0000	++	++	++

Table D-6--Margins of safety for workers
Nursery: Bessey
Pesticide: Benomyl

	Exposure (mg/kg/day)	Margin of safety relative to: LD_{50} (10000.0)	Systemic NOEL (12.50)	Reproductive NOEL (5.00)
Average				
Applicator	0.0006	++	++	++
Weeder	0.0444	++	280	110
Inventory	0.0137	++	910	360
Lifting	0.0007	++	++	++
Extreme				
Applicator	0.0012	++	++	++
Weeder	0.0773	++	160	65
Inventory	0.0773	++	160	65
Lifting	0.0097	++	++	510
Accident spray	0.2100	++	60	24
Accident spill	---	---	---	---
Premature reentry	0.0856	++	150	58

Margins of Safety for Exposed Members of the Public

	Exposure (mg/kg/day)	Margin of safety relative to: LD_{50} (10000.0)	Systemic NOEL (12.50)	Reproductive NOEL (5.00)
Average over applications				
Dietary exposures				
Beef	0.0000	++	++	++
Rabbit	0.0009	++	++	++
Grouse	0.0007	++	++	++
Vegs., 25 feet	0.0023	++	++	++
Vegs., 100 feet	0.0016	++	++	++
Water, runoff	---	---	---	---
Water, drift	0.0000	++	++	++
Dermal exposures				
At 25 feet	0.0007	++	++	++
At 100 feet	0.0005	++	++	++
Dog petting	0.0000	++	++	++
Lowest margins of safety				
Dietary exposures				
Beef	0.0000	++	++	++
Rabbit	0.0009	++	++	++
Grouse	0.0007	++	++	++
Vegs., 25 feet	0.0023	++	++	++
Vegs., 100 feet	0.0016	++	++	++
Water, runoff	---	---	---	---
Water, drift	0.0000	++	++	++
Dermal exposures				
At 25 feet	0.0007	++	++	++
At 100 feet	0.0005	++	++	++
Dog petting	0.0000	++	++	++

Table D-7--Margins of safety for workers
Nursery: Bessey
Pesticide: Chlorothalonil

	Exposure (mg/kg/day)	Margin of safety relative to: LD_{50} (10000.0)	Systemic NOEL (1.50)	Reproductive NOEL (5.00)
Average				
Applicator	0.0023	++	640	++
Weeder	0.1230	++	12	41
Inventory	0.0540	++	28	93
Lifting	0.0090	++	170	560
Extreme				
Applicator	0.0052	++	290	960
Weeder	0.2158	++	7.0	23
Inventory	0.1640	++	9.1	30
Lifting	0.1322	++	11	38
Accident spray	0.5800	++	2.6	8.6
Accident spill	360.0000	28	-240	-72
Premature reentry	0.2397	++	6.3	21

Margins of Safety for Exposed Members of the Public

	Exposure (mg/kg/day)	Margin of safety relative to: LD_{50} (10000.0)	Systemic NOEL (1.50)	Reproductive NOEL (5.00)
Average over applications				
Dietary exposures				
Beef	0.0001	++	++	++
Rabbit	0.0024	++	630	++
Grouse	0.0020	++	750	++
Vegs., 25 feet	0.0066	++	230	760
Vegs., 100 feet	0.0045	++	330	++
Water, runoff	---	---	---	---
Water, drift	0.0000	++	++	++
Dermal exposures				
At 25 feet	0.0020	++	750	++
At 100 feet	0.0013	++	++	++
Dog petting	0.0001	++	++	++
Lowest margins of safety				
Dietary exposures				
Beef	0.0001	++	++	++
Rabbit	0.0024	++	630	++
Grouse	0.0020	++	750	++
Vegs., 25 feet	0.0066	++	230	760
Vegs., 100 feet	0.0045	++	330	++
Water, runoff	---	---	---	---
Water, drift	0.0000	++	++	++
Dermal exposures				
At 25 feet	0.0020	++	750	++
At 100 feet	0.0013	++	++	++
Dog petting	0.0001	++	++	++

Table D-8--Margins of safety for workers
Nursery: Bessey
Pesticide: Carbaryl

	Exposure (mg/kg/day)	Margin of safety relative to: LD_{50} (270.0)	Systemic NOEL (10.00)	Reproductive NOEL (3.13)
Average				
Applicator	0.0001	++	++	++
Weeder	0.0405	++	250	77
Inventory	0.0019	++	++	++
Lifting	0.0000	++	++	++
Extreme				
Applicator	0.0003	++	++	++
Weeder	0.1053	++	95	30
Inventory	0.0185	++	540	170
Lifting	0.0000	++	++	++
Accident spray	0.3300	820	30	9.5
Accident spill	240.0000	1.1	-24	-77
Premature reentry	0.1361	++	73	23

Margins of Safety for Exposed Members of the Public

	Exposure (mg/kg/day)	Margin of safety relative to: LD_{50} (270.0)	Systemic NOEL (10.00)	Reproductive NOEL (3.13)
Average over applications				
Dietary exposures				
Beef	0.0001	++	++	++
Rabbit	0.0014	++	++	++
Grouse	0.0011	++	++	++
Vegs., 25 feet	0.0037	++	++	840
Vegs., 100 feet	0.0026	++	++	++
Water, runoff	---	---	---	---
Water, drift	0.0000	++	++	++
Dermal exposures				
At 25 feet	0.0012	++	++	++
At 100 feet	0.0007	++	++	++
Dog petting	0.0001	++	++	++
Lowest margins of safety				
Dietary exposures				
Beef	0.0001	++	++	++
Rabbit	0.0014	++	++	++
Grouse	0.0011	++	++	++
Vegs., 25 feet	0.0037	++	++	840
Vegs., 100 feet	0.0026	++	++	++
Water, runoff	---	---	---	---
Water, drift	0.0000	++	++	++
Dermal exposures				
At 25 feet	0.0012	++	++	++
At 100 feet	0.0007	++	++	++
Dog petting	0.0001	++	++	++

Table D-9--Margins of safety for workers
Nursery: Bessey
Pesticide: Dimethoate

	Exposure (mg/kg/day)	Margin of safety relative to: LD_{50} (250.0)	Systemic NOEL (0.20)	Reproductive NOEL (7.50)
Average				
Applicator	0.0004	++	450	++
Weeder	0.0217	++	9.2	350
Inventory	0.0073	++	27	1000
Lifting	0.0000	++	++	++
Extreme				
Applicator	0.0010	++	200	++
Weeder	0.0630	++	3.2	120
Inventory	0.0290	++	6.9	260
Lifting	0.0000	++	++	++
Accident spray	0.2100	++	-1.0	36
Accident spill	240.0000	1.0	-1200	-32
Premature reentry	0.0849	++	2.4	88

Margins of Safety for Exposed Members of the Public

	Exposure (mg/kg/day)	Margin of safety relative to: LD_{50} (250.0)	Systemic NOEL (0.20)	Reproductive NOEL (7.50)
Average over applications				
Dietary exposures				
Beef	0.0000	++	++	++
Rabbit	0.0009	++	230	++
Grouse	0.0007	++	290	++
Vegs., 25 feet	0.0023	++	87	++
Vegs., 100 feet	0.0016	++	130	++
Water, runoff	---	---	---	---
Water, drift	0.0000	++	++	++
Dermal exposures				
At 25 feet	0.0007	++	280	++
At 100 feet	0.0005	++	430	++
Dog petting	0.0000	++	++	++
Lowest margins of safety				
Dietary exposures				
Beef	0.0000	++	++	++
Rabbit	0.0009	++	230	++
Grouse	0.0007	++	290	++
Vegs., 25 feet	0.0023	++	87	++
Vegs., 100 feet	0.0016	++	130	++
Water, runoff	---	---	---	---
Water, drift	0.0000	++	++	++
Dermal exposures				
At 25 feet	0.0007	++	280	++
At 100 feet	0.0005	++	430	++
Dog petting	0.0000	++	++	++

Table D-10--Lifetime cancer risk for exposed members of the public
Nursery: Bessey

	Oxyfluorfen	Glyphosate	Chlorothalonil	Benomyl	Carbaryl	Dimethoate
5 Exposures						
Rabbit	2.E-12	3.E-12	1.E-08	1.E-09	4.E-08	1.E-08
Vegs. (25 ft)	7.E-12	9.E-12	3.E-08	3.E-09	1.E-07	3.E-08
Water, drift	5.E-13	4.E-13	4.E-11	5.E-11	1.E-09	1.E-10
Dermal (25 ft)	2.E-12	3.E-12	9.E-09	9.E-10	----	9.E-09
30 Exposures						
Rabbit	1.E-11	2.E-11	7.E-08	7.E-09	2.E-07	7.E-08
Vegs. (25 ft)	4.E-11	5.E-11	2.E-07	2.E-08	6.E-07	2.E-07
Water, drift	3.E-12	2.E-12	2.E-10	3.E-10	6.E-09	6.E-10
Dermal (25 ft)	1.E-11	2.E-11	6.E-08	6.E-09	----	6.E-08

Table D-11--Lifetime cancer risk for workers
Nursery: Bessey

	Oxyfluorfen	Glyphosate	Chlorothalonil	Benomyl	Dimethoate
5 Years of exposure					
Weeding	4.E-11	----	8.E-06	5.E-07	2.E-06
Inventory	3.E-12	----	1.E-06	7.E-08	3.E-07
Lifting	4.E-14	----	4.E-07	6.E-09	5.E-14
Application	2.E-14	8.E-14	4.E-09	4.E-10	3.E-09
30 Years of exposure					
Weeding	2.E-10	----	5.E-05	3.E-06	1.E-05
Inventory	2.E-11	----	9.E-06	4.E-07	2.E-06
Lifting	3.E-13	----	3.E-06	4.E-08	3.E-13
Application	1.E-13	5.E-13	3.E-08	3.E-09	2.E-08

E. Coeur d'Alene Nursery

EXPOSURE ANALYSIS METHODS

The Coeur d'Alene Nursery is located in Idaho and has a total area of 220 acres and a total nursery bed area of 131 acres. Approximately 131 acres are treated with pesticides every year. The nursery generally employs the following number of personnel annually for its operations: 2 to 3 mixer/loader/applicators, 11 to 24 weeders, 4 to 6 inventory personnel, 100 to 200 lifters, 160 to 300 sorters and packers, 2 fumigators, and 3 tarp lifters.

The exposure analysis methods used to estimate doses to workers and the public in the Coeur d'Alene Nursery were similar to those described for the generic nursery, except that the conditions specific to the nursery, such as the pesticides used, the application rates, and the timing of the applications, were used in the analyses rather than the generic set of conditions. The pesticide application schedule for the nursery is shown in table E-1. (Tables can be found at the end of this section.) For the purposes of determining foliar washoff of pesticide residues, each bed was assumed to be irrigated every other day at a rate of 0.13 to 0.14 inches per day. Methyl bromide and chloropicrin are applied to approximately 30 acres in August, and dazomet is applied to approximately 25 acres also in August.

There are two Forest Service residences onsite and 17 residences within 100 feet. The land bordering the nursery is residential or forested.

The nearest live water is a river approximately 2 miles from the nursery boundary. An aquifer is located at a depth of 250 feet. The soil is predominantly sandy loam to loamy sand.

RISK ANALYSIS

Risk of Systemic and Reproductive Effects

Risks to members of the public and workers involved in pesticide applications and related nursery tasks in the Coeur D'Alene Nursery are based on the methods described in chapters 3 and 4 of the generic nursery risk assessment. Tables E-2 through E-9 present exposure levels and margins of safety based on LD_{50}'s, systemic NOEL's, and reproductive NOEL's for routine-realistic (average), routine-extreme, and accidental exposures.

The MOS tables for each chemical consist of two parts. The first lists worker exposures and MOS's for the chemical as it is used in the Coeur D'Alene Nursery. The worker portion lists MOS's for routine-realistic (average), routine-extreme (extreme), and accidental exposures (spraying, spills on the skin, and premature reentry). LD_{50}'s and NOEL's are listed above each column of MOS's.

The second portion of each table lists public exposures and MOS's via specific exposure routes for routine-realistic (average) and routine-extreme (lowest MOS's) exposures. The only accidents that may affect the public are assumed to be those involving fumigant spills. The analysis of fumigant spills is contained in the generic nursery risk analysis.

Dashes in the worker portion of the tables indicate that the chemical is used only in cover crops. Dashes in the public portion indicate that the route of exposure is not considered a significant one in this analysis. Margins of safety greater than 1,000 are indicated by ++.

Where MOS's are greater than 100, risk can be considered negligible for the chemical in question. MOS's between 10 and 100 indicate a slight risk of low-level toxic effects--to sensitive individuals in particular. MOS's between 1 and 10 indicate a moderate risk of low-level toxic effects, especially in light of the uncertainty in extrapolating from laboratory test animal species to humans. Risk may be significant where an MOS for a chemical is negative (the estimated exposure exceeds the animal NOEL). Refer to the discussion of low-level toxic effects in the generic nursery risk analysis.

Cancer Risk

Lifetime cancer risks for chlorothalonil and benomyl to members of the public at the Coeur D'Alene Nursery are listed in table E-10 for different exposure routes and numbers of lifetime exposures. Lifetime cancer risk to workers from the use of those chemicals in various nursery tasks are listed in table E-11. The cancer risk tables should be interpreted as follows. Where the exponent is lower, the risk is higher. For example, a risk value of 1.0E-06 (1 chance in 1 million) is lower than a risk of 1.0E-05 (1 chance in 100,000). A risk of 7.0E-06 exceeds a risk of 1.0E-06.

In general, risk may be considered acceptable when risk to an individual is equal to or lower than 1 in 1 million. Where risk exceeds 1 chance in 100,000, proper precautions that reduce exposure levels may, in turn, reduce the cancer risk to acceptable levels.

Table E-1--Coeur d'Alene Nursery schedule for pesticide applications (based on average use)

Crop	Year	Chemical	Acres	Rate (lb/acre)	Applications per year	Month of application
Cover crop	0	None	--	--	--	--
Pine	1	Napropamide	6.7	1.5	1	Apr
Pine	1	Diphenamid	6.7	4.0	5	Apr-Aug
Douglas-fir	1	Napropamide	6.7	1.5	1	Apr
Spruce	1	Diphenamid	3.3	4.0	5	Apr-Aug
Other conifers	1	Napropamide	6.6	1.5	1	Apr
Pine	2	DCPA	5.0	10.5	1	Apr
Pine	2	Diphenamid	9.4	4.0	1	Apr
Douglas-fir	2	Napropamide	5.0	1.5	1	Apr
Douglas-fir	2	Diazinon	5.0	1.0	2-3	Jun-Jul
Douglas-fir	2	Metalaxyl	15.0	1.25	1	Sep
Douglas-fir	2	Chlorpyrifos	9.0	1.0	1	Aug
Spruce	2	Diphenamid	4.7	4.0	1	Apr
Spruce	2	Metalaxyl	15.0	1.25	1	Sep
Spruce	2	Chlorpyrifos	9.0	1.0	1	Aug
Other conifers	2	Napropamide	5.0	1.5	1	Apr
Other conifers	2	Chlorothalonil	10.0	1.5	3	Apr-Jun
Other conifers	2	Benomyl	10.0	1.0	3	Apr-Jun
Other conifers	2	Metalaxyl	15.0	1.25	1	Sep
Other conifers	2	Chlorpyrifos	9.0	1.0	1	Aug
Douglas-fir	3	Napropamide	1.0	1.5	1	Apr

Table E-2--Margins of safety for workers
Nursery: Coeur d'Alene
Pesticide: DCPA

	Exposure (mg/kg/day)	Margin of safety relative to: LD_{50} (10250.0)	Systemic NOEL (50.00)	Reproductive NOEL (50.00)
Average				
Applicator	0.0110	++	++	++
Weeder	0.3928	++	130	130
Inventory	0.3196	++	160	160
Lifting	0.0128	++	++	++
Extreme				
Applicator	0.0244	++	++	++
Weeder	1.3532	++	37	37
Inventory	1.3532	++	37	37
Lifting	0.0160	++	++	++
Accident spray	4.4000	++	11	11
Accident spill	360.0000	28	-7.2	-7.2
Premature reentry	1.8001	++	28	28

Margins of Safety for Exposed Members of the Public

	Exposure (mg/kg/day)	Margin of safety relative to: LD_{50} (10250.0)	Systemic NOEL (50.00)	Reproductive NOEL (50.00)
Average over applications				
Dietary exposures				
Beef	0.0009	++	++	++
Rabbit	0.0180	++	++	++
Grouse	0.0150	++	++	++
Vegs., 25 feet	0.0490	++	1000	1000
Vegs., 100 feet	0.0340	++	++	++
Water, runoff	---	---	---	---
Water, drift	---	---	---	---
Dermal exposures				
At 25 feet	0.0150	++	++	++
At 100 feet	0.0097	++	++	++
Dog petting	0.0010	++	++	++
Lowest margins of safety				
Dietary exposures				
Beef	0.0009	++	++	++
Rabbit	0.0180	++	++	++
Grouse	0.0150	++	++	++
Vegs., 25 feet	0.0490	++	1000	1000
Vegs., 100 feet	0.0340	++	++	++
Water, runoff	---	---	---	---
Water, drift	---	---	---	---
Dermal exposures				
At 25 feet	0.0150	++	++	++
At 100 feet	0.0097	++	++	++
Dog petting	0.0010	++	++	++

Table E-3--Margins of safety for workers
Nursery: Coeur d'Alene
Pesticide: Diphenamid

	Exposure (mg/kg/day)	Margin of safety relative to: LD_{50} (1373.0)	Systemic NOEL (3.00)	Reproductive NOEL (10.00)
Average				
Applicator	0.0045	++	670	++
Weeder	0.0234	++	130	430
Inventory	0.0033	++	910	++
Lifting	0.0000	++	++	++
Extreme				
Applicator	0.0175	++	170	570
Weeder	0.3343	++	9.0	30
Inventory	0.3343	++	9.0	30
Lifting	0.0000	++	++	++
Accident spray	1.7000	810	1.8	5.9
Accident spill	---	---	---	---
Premature reentry	0.6822	++	4.4	15

Margins of Safety for Exposed Members of the Public

	Exposure (mg/kg/day)	Margin of safety relative to: LD_{50} (1373.0)	Systemic NOEL (3.00)	Reproductive NOEL (10.00)
Average over applications				
Dietary exposures				
Beef	0.0003	++	++	++
Rabbit	0.0069	++	430	++
Grouse	0.0056	++	540	++
Vegs., 25 feet	0.0190	++	160	530
Vegs., 100 feet	0.0130	++	230	770
Water, runoff	---	---	---	---
Water, drift	---	---	---	---
Dermal exposures				
At 25 feet	0.0058	++	520	++
At 100 feet	0.0037	++	810	++
Dog petting	0.0004	++	++	++
Lowest margins of safety				
Dietary exposures				
Beef	0.0003	++	++	++
Rabbit	0.0069	++	430	++
Grouse	0.0056	++	540	++
Vegs., 25 feet	0.0190	++	160	530
Vegs., 100 feet	0.0130	++	230	770
Water, runoff	---	---	---	---
Water, drift	---	---	---	---
Dermal exposures				
At 25 feet	0.0058	++	520	++
At 100 feet	0.0037	++	810	++
Dog petting	0.0004	++	++	++

Table E-4--Margins of safety for workers
Nursery: Coeur d'Alene
Pesticide: Napropamide

	Exposure (mg/kg/day)	Margin of safety relative to: LD_{50} (5000.0)	Systemic NOEL (25.00)	Reproductive NOEL (10.00)
Average				
Applicator	0.0018	++	++	++
Weeder	0.0023	++	++	++
Inventory	0.0102	++	++	980
Lifting	0.0000	++	++	++
Extreme				
Applicator	0.0047	++	++	++
Weeder	0.0920	++	270	110
Inventory	0.0920	++	270	110
Lifting	0.0000	++	++	++
Accident spray	0.6300	++	40	16
Accident spill	120.0000	42	-4.8	-12
Premature reentry	0.2549	++	98	39

Margins of Safety for Exposed Members of the Public

	Exposure (mg/kg/day)	Margin of safety relative to: LD_{50} (5000.0)	Systemic NOEL (25.00)	Reproductive NOEL (10.00)
Average over applications				
Dietary exposures				
Beef	0.0001	++	++	++
Rabbit	0.0026	++	++	++
Grouse	0.0021	++	++	++
Vegs., 25 feet	0.0070	++	++	++
Vegs., 100 feet	0.0048	++	++	++
Water, runoff	---	---	---	---
Water, drift	---	---	---	---
Dermal exposures				
At 25 feet	0.0022	++	++	++
At 100 feet	0.0014	++	++	++
Dog petting	0.0001	++	++	++
Lowest margins of safety				
Dietary exposures				
Beef	0.0001	++	++	++
Rabbit	0.0026	++	++	++
Grouse	0.0021	++	++	++
Vegs., 25 feet	0.0070	++	++	++
Vegs., 100 feet	0.0048	++	++	++
Water, runoff	---	---	---	---
Water, drift	---	---	---	---
Dermal exposures				
At 25 feet	0.0022	++	++	++
At 100 feet	0.0014	++	++	++
Dog petting	0.0001	++	++	++

Table E-5--Margins of safety for workers
Nursery: Coeur d'Alene
Pesticide: Chlorpyrifos

		Margin of safety relative to:		
	Exposure (mg/kg/day)	LD_{50} (137.0)	Systemic NOEL (0.03)	Reproductive NOEL (0.10)
Average				
Applicator	0.0019	++	16	53
Weeder	0.0228	++	1.3	4.4
Inventory	0.0040	++	7.4	25
Lifting	0.0000	++	++	++
Extreme				
Applicator	0.0042	++	7.2	24
Weeder	0.1049	++	-3.5	-1.0
Inventory	0.0304	++	-1.0	3.3
Lifting	0.0000	++	++	++
Accident spray	0.4200	330	-14	-4.2
Accident spill	240.0000	-1.8	-8000	-2400
Premature reentry	0.1685	810	-5.6	-1.7

Margins of Safety for Exposed Members of the Public

		Margin of safety relative to:		
	Exposure (mg/kg/day)	LD_{50} (137.0)	Systemic NOEL (0.03)	Reproductive NOEL (0.10)
Average over applications				
Dietary exposures				
Beef	0.0000	++	610	++
Rabbit	0.0017	++	18	59
Grouse	0.0014	++	21	71
Vegs., 25 feet	0.0047	++	6.4	21
Vegs., 100 feet	0.0032	++	9.4	31
Water, runoff	---	---	---	---
Water, drift	---	---	---	---
Dermal exposures				
At 25 feet	0.0014	++	21	71
At 100 feet	0.0009	++	33	110
Dog petting	0.0001	++	320	++
Lowest margins of safety				
Dietary exposures				
Beef	0.0000	++	610	++
Rabbit	0.0017	++	18	59
Grouse	0.0014	++	21	71
Vegs., 25 feet	0.0047	++	6.4	21
Vegs., 100 feet	0.0032	++	9.4	31
Water, runoff	---	---	---	---
Water, drift	---	---	---	---
Dermal exposures				
At 25 feet	0.0014	++	21	71
At 100 feet	0.0009	++	33	110
Dog petting	0.0001	++	320	++

Table E-6--Margins of safety for workers
Nursery: Coeur d'Alene
Pesticide: Metalaxyl

	Exposure (mg/kg/day)	Margin of safety relative to: LD_{50} (669.0)	Systemic NOEL (6.25)	Reproductive NOEL (50.00)
Average				
Applicator	0.0039	++	++	++
Weeder	0.0718	++	87	700
Inventory	0.0143	++	440	++
Lifting	0.0000	++	++	++
Extreme				
Applicator	0.0087	++	720	++
Weeder	0.1707	++	37	290
Inventory	0.1707	++	37	290
Lifting	0.0003	++	++	++
Accident spray	0.5200	++	12	96
Accident spill	120.0000	5.6	-19	-2.4
Premature reentry	0.2130	++	29	230

Margins of Safety for Exposed Members of the Public

	Exposure (mg/kg/day)	Margin of safety relative to: LD_{50} (669.0)	Systemic NOEL (6.25)	Reproductive NOEL (50.00)
Average over applications				
Dietary exposures				
Beef	0.0001	++	++	++
Rabbit	0.0021	++	++	++
Grouse	0.0018	++	++	++
Vegs., 25 feet	0.0059	++	++	++
Vegs., 100 feet	0.0040	++	++	++
Water, runoff	---	---	---	---
Water, drift	---	---	---	---
Dermal exposures				
At 25 feet	0.0018	++	++	++
At 100 feet	0.0011	++	++	++
Dog petting	0.0001	++	++	++
Lowest margins of safety				
Dietary exposures				
Beef	0.0001	++	++	++
Rabbit	0.0021	++	++	++
Grouse	0.0018	++	++	++
Vegs., 25 feet	0.0059	++	++	++
Vegs., 100 feet	0.0040	++	++	++
Water, runoff	---	---	---	---
Water, drift	---	---	---	---
Dermal exposures				
At 25 feet	0.0018	++	++	++
At 100 feet	0.0011	++	++	++
Dog petting	0.0001	++	++	++

Table E-7--Margins of safety for workers
Nursery: Coeur d'Alene
Pesticide: Chlorothalonil

	Exposure (mg/kg/day)	Margin of safety relative to: LD_{50} (10000.0)	Systemic NOEL (1.50)	Reproductive NOEL (5.00)
Average				
Applicator	0.0031	++	480	++
Weeder	0.1467	++	10	34
Inventory	0.0810	++	19	62
Lifting	0.0240	++	63	210
Extreme				
Applicator	0.0070	++	220	720
Weeder	0.2384	++	6.3	21
Inventory	0.1956	++	7.7	26
Lifting	0.1781	++	8.4	28
Accident spray	0.6300	++	2.4	7.9
Accident spill	360.0000	28	-240	-72
Premature reentry	0.2572	++	5.8	19

Margins of Safety for Exposed Members of the Public

	Exposure (mg/kg/day)	Margin of safety relative to: LD_{50} (10000.0)	Systemic NOEL (1.50)	Reproductive NOEL (5.00)
Average over applications				
Dietary exposures				
Beef	0.0001	++	++	++
Rabbit	0.0026	++	580	++
Grouse	0.0021	++	710	++
Vegs., 25 feet	0.0070	++	210	710
Vegs., 100 feet	0.0048	++	310	1000
Water, runoff	---	---	---	---
Water, drift	---	---	---	---
Dermal exposures				
At 25 feet	0.0022	++	680	++
At 100 feet	0.0014	++	++	++
Dog petting	0.0001	++	++	++
Lowest margins of safety				
Dietary exposures				
Beef	0.0001	++	++	++
Rabbit	0.0026	++	580	++
Grouse	0.0021	++	710	++
Vegs., 25 feet	0.0070	++	210	710
Vegs., 100 feet	0.0048	++	310	1000
Water, runoff	---	---	---	---
Water, drift	---	---	---	---
Dermal exposures				
At 25 feet	0.0022	++	680	++
At 100 feet	0.0014	++	++	++
Dog petting	0.0001	++	++	++

Table E-8--Margins of safety for workers
Nursery: Coeur d'Alene
Pesticide: Benomyl

	Exposure (mg/kg/day)	Margin of safety relative to: LD_{50} (10000.0)	Systemic NOEL (12.50)	Reproductive NOEL (5.00)
Average				
Applicator	0.0021	++	++	++
Weeder	0.0988	++	130	51
Inventory	0.0427	++	290	120
Lifting	0.0055	++	++	900
Extreme				
Applicator	0.0047	++	++	++
Weeder	0.1594	++	78	31
Inventory	0.1594	++	78	31
Lifting	0.0386	++	320	130
Accident spray	0.4200	++	30	12
Accident spill	---	---	---	---
Premature reentry	0.1715	++	73	29

Margins of Safety for Exposed Members of the Public

	Exposure (mg/kg/day)	Margin of safety relative to: LD_{50} (10000.0)	Systemic NOEL (12.50)	Reproductive NOEL (5.00)
Average over applications				
Dietary exposures				
Beef	0.0001	++	++	++
Rabbit	0.0017	++	++	++
Grouse	0.0014	++	++	++
Vegs., 25 feet	0.0047	++	++	++
Vegs., 100 feet	0.0032	++	++	++
Water, runoff	---	---	---	---
Water, drift	---	---	---	---
Dermal exposures				
At 25 feet	0.0014	++	++	++
At 100 feet	0.0009	++	++	++
Dog petting	0.0001	++	++	++
Lowest margins of safety				
Dietary exposures				
Beef	0.0001	++	++	++
Rabbit	0.0017	++	++	++
Grouse	0.0014	++	++	++
Vegs., 25 feet	0.0047	++	++	++
Vegs., 100 feet	0.0032	++	++	++
Water, runoff	---	---	---	---
Water, drift	---	---	---	---
Dermal exposures				
At 25 feet	0.0014	++	++	++
At 100 feet	0.0009	++	++	++
Dog petting	0.0001	++	++	++

Table E-9--Margins of safety for workers
Nursery: Coeur d'Alene
Pesticide: Diazinon

		Margin of safety relative to:		
	Exposure (mg/kg/day)	LD_{50} (250.0)	Systemic NOEL (0.02)	Reproductive NOEL (0.20)
Average				
Applicator	0.0010	++	19	190
Weeder	0.0436	++	-2.2	4.6
Inventory	0.0003	++	77	770
Lifting	0.0000	++	++	++
Extreme				
Applicator	0.0023	++	8.6	86
Weeder	0.1261	++	-6.3	1.6
Inventory	0.0077	++	2.6	26
Lifting	0.0000	++	++	++
Accident spray	0.4200	600	-21	-2.1
Accident spill	360.0000	-1.4	-18000	-1800
Premature reentry	0.1698	++	-8.5	1.2

Margins of Safety for Exposed Members of the Public

		Margin of safety relative to:		
	Exposure (mg/kg/day)	LD_{50} (250.0)	Systemic NOEL (0.02)	Reproductive NOEL (0.20)
Average over applications				
Dietary exposures				
Beef	0.0001	++	320	++
Rabbit	0.0017	++	12	120
Grouse	0.0014	++	14	140
Vegs., 25 feet	0.0047	++	4.3	43
Vegs., 100 feet	0.0032	++	6.3	63
Water, runoff	---	---	---	---
Water, drift	---	---	---	---
Dermal exposures				
At 25 feet	0.0014	++	14	140
At 100 feet	0.0009	++	22	220
Dog petting	0.0001	++	210	++
Lowest margins of safety				
Dietary exposures				
Beef	0.0001	++	320	++
Rabbit	0.0017	++	12	120
Grouse	0.0014	++	14	140
Vegs., 25 feet	0.0047	++	4.3	43
Vegs., 100 feet	0.0032	++	6.3	63
Water, runoff	---	---	---	---
Water, drift	---	---	---	---
Dermal exposures				
At 25 feet	0.0014	++	14	140
At 100 feet	0.0009	++	22	220
Dog petting	0.0001	++	210	++

Table E-10--Lifetime cancer risk for exposed members of the public
Nursery: Coeur d'Alene

	Chlorothalonil	Benomyl
5 Exposures		
Rabbit	1.E-08	2.E-09
Vegs. (25 ft)	3.E-08	6.E-09
Water, drift	----	----
Dermal (25 ft)	1.E-08	2.E-09
30 Exposures		
Rabbit	7.E-08	1.E-08
Vegs. (25 ft)	2.E-07	4.E-08
Water, drift	----	----
Dermal (25 ft)	6.E-08	1.E-08

Table E-11--Lifetime cancer risk for workers
Nursery: Coeur d'Alene

	Chlorothalonil	Benomyl
5 Years of exposure		
Weeding	4.E-06	7.E-07
Inventory	9.E-07	1.E-07
Lifting	5.E-07	3.E-08
Application	7.E-09	1.E-09
30 Years of exposure		
Weeding	2.E-05	4.E-06
Inventory	6.E-06	8.E-07
Lifting	3.E-06	2.E-07
Application	4.E-08	8.E-09

F. Humbolt Nursery

EXPOSURE ANALYSIS METHODS

The Humboldt Nursery is located in California and has a total area of 209 acres and a total nursery bed area of 133 acres. Forty bed-acres are treated with pesticides every year. The nursery generally employs the following number of personnel annually for its operations: 2 mixer/loader/applicators, 11 to 24 weeders, 4 to 6 inventory personnel, 15 to 30 lifters, 80 to 96 sorters and packers, 6 to 11 fumigators, and 5 to 6 tarp lifters.

The exposure analysis methods used to estimate doses to workers and the public in the Humboldt Nursery were similar to those described for the generic nursery, except that the conditions specific to the nursery, such as the pesticides used, the application rates, and the timing of the applications, were used in the analyses rather than the generic set of conditions. The pesticide application schedule for the nursery is given in table F-1. (Tables can be found at the end of this section.)

The Humboldt Nursery uses chlorothalonil as a fungicide at 2-week intervals throughout the winter. The following reentry times were used to analyze worker exposure to chlorothalonil after winter application. For weeders under the routine-realistic scenario, the average time to reentry is 60 days. For the routine-extreme scenario, the worst case reentry is 2 days. For inventory personnel, under the routine-realistic scenario, the average time to reentry is 45 days. For the routine-extreme scenario, the worst case reentry time is 2 days. For lifters, sorters, and packers, under the routine-realistic scenario, the average time to lifting is 60 days; for the routine-extreme case, the worst case reentry time is 2 days.

Irrigation of a nursery bed may be performed immediately after an herbicide has been applied to the crop, or at least 24 hours after application of a fungicide. Methyl bromide and chloropicrin are applied to approximately 20 acres in September. From January to February, seeds are treated with captan and in April and May seeds are treated with thiram.

There is one Forest Service residence onsite; no other occupied residences occur within 100 feet of the nursery boundary. The land bordering the nursery is predominantly farmland and forest.

The nearest live water is a creek approximately 700 feet from the nursery boundary. There is no aquifer below the nursery. The nursery soils are fine sandy loam.

RISK ANALYSIS

Risk of Systemic and Reproductive Effects

Risks to members of the public and workers involved in pesticide applications and related nursery tasks in the Humboldt Nursery are based on the methods described in chapters 3 and 4 of the generic nursery risk

assessment. Tables F-2 through F-7 present exposure levels and margins of safety based on LD_{50}'s, systemic NOEL's, and reproductive NOEL's for routine-realistic (average), routine-extreme, and accidental exposures.

The MOS tables for each chemical consist of two parts. The first lists worker exposures and MOS's for the chemical as it is used in the Humboldt Nursery. The worker portion lists MOS's for routine-realistic (average), routine-extreme (extreme), and accidental exposures (spraying, spills on the skin, and premature reentry). LD_{50}'s and NOEL's are listed above each column of MOS's.

The second portion of each table lists public exposures and MOS's via specific exposure routes for routine-realistic (average) and routine-extreme (lowest MOS's) exposures. The only accidents that may affect the public are assumed to be those involving fumigant spills. The analysis of fumigant spills is contained in the generic nursery risk analysis.

Dashes in the worker portion of the tables indicate that the chemical is used only in cover crops. Dashes in the public portion indicate that the route of exposure is not considered a significant one in this analysis. Margins of safety greater than 1,000 are indicated by ++.

Where MOS's are greater than 100, risk can be considered negligible for the chemical in question. MOS's between 10 and 100 indicate a slight risk of low-level toxic effects--to sensitive individuals in particular. MOS's between 1 and 10 indicate a moderate risk of low-level toxic effects, especially in light of the uncertainty in extrapolating from laboratory test animal species to humans. Risk may be significant where an MOS for a chemical is negative (the estimated exposure exceeds the animal NOEL). Refer to the discussion of low-level toxic effects in the generic nursery risk analysis.

Cancer Risk

Lifetime cancer risks for the known or suspected carcinogenic chemicals oxyfluorfen, benomyl, glyphosate, chlorothalonil, and benomyl to members of the public at the Humboldt Nursery are listed in table F-8 for different exposure routes and numbers of lifetime exposures. Lifetime cancer risk to workers from the use of those chemicals in various nursery tasks are listed in table F-9. The cancer risk tables should be interpreted as follows. Where the exponent is lower, the risk is higher. For example, a risk value of 1.0E-06 (1 chance in 1 million) is lower than a risk of 1.0E-05 (1 chance in 100,000). A risk of 7.0E-06 exceeds a risk of 1.0E-06.

In general, risk may be considered acceptable where risk to an individual is equal to or lower than 1 in 1 million. Where risk exceeds 1 chance in 100,000, proper precautions that reduce exposure levels may, in turn, reduce the cancer risk to acceptable levels.

Table F-1--Humboldt Nursery schedule for pesticide applications (based on average use)

Crop	Year	Chemical	Acres	Rate (lb/acre)	Applications per year	Month of application
Cover crop	0	Glyphosate	20.0	2.0	1-2	Mar-Apr
Pine	1	Bifenox	1.0	3.0	1	Jun
Douglas fir	1	Oxyfluorfen	15.0	0.5	1-2	Mar-Apr
Other conifers	1	Bifenox	1.0	3.0	1-2	Mar-Apr
Douglas-fir	1	Bifenox	15.0	3.0	1	Jun
Pine	2	Oxyfluorfen	1.0	0.5	1	Mar
Douglas-fir	2	Oxyfluorfen	15.0	0.5	1	Mar
Douglas-fir	2	Chlorothalonil	15.0	1.5	12	Oct-Mar
Douglas-fir	2	Benomyl	15.0	0.5	1	May
Douglas-fir	2	Bifenox	15.0	3.0	1	Jun
Other conifers	2	Chlorothalonil	1.0	1.5	12	Oct-Mar
Other conifers	2	Benomyl	1.0	3.0	1	Mar
Other conifers	2	Bifenox	1.0	3.0	1	Jun
Pine	2	Triadimefon	1.0	0.5	7	Mar-Sep
Seed treatment		Captan		1 tsp/gal water		Before sowing
Seed treatment		Thiram				Before sowing

*Applied at 2-week intervals through the winter.

Table F-2--Margins of safety for workers
Nursery: Humboldt
Pesticide: Bifenox

		Margin of safety relative to:		
	Exposure (mg/kg/day)	LD_{50} (6400.0)	Systemic NOEL (12.50)	Reproductive NOEL (10.00)
Average				
Applicator	0.0085	++	++	++
Weeder	0.0100	++	++	1000
Inventory	0.0208	++	600	480
Lifting	0.0000	++	++	++
Extreme				
Applicator	0.0209	++	600	480
Weeder	0.2201	++	57	45
Inventory	0.4045	++	31	25
Lifting	0.0000	++	++	++
Accident spray	1.3000	++	9.6	7.7
Accident spill	120.0000	53	-9.6	-12
Premature reentry	0.5109	++	24	20

Margins of Safety for Exposed Members of the Public

		Margin of safety relative to:		
	Exposure (mg/kg/day)	LD_{50} (6400.0)	Systemic NOEL (12.50)	Reproductive NOEL (10.00)
Average over applications				
Dietary exposures				
Beef	0.0002	++	++	++
Rabbit	0.0052	++	++	++
Grouse	0.0042	++	++	++
Vegs., 25 feet	0.0140	++	890	710
Vegs., 100 feet	0.0097	++	++	1000
Water, runoff	---	---	---	---
Water, drift	---	---	---	---
Dermal exposures				
At 25 feet	0.0043	++	++	++
At 100 feet	0.0028	++	++	++
Dog petting	0.0003	++	++	++
Lowest margins of safety				
Dietary exposures				
Beef	0.0002	++	++	++
Rabbit	0.0052	++	++	++
Grouse	0.0042	++	++	++
Vegs., 25 feet	0.0140	++	890	710
Vegs., 100 feet	0.0097	++	++	1000
Water, runoff	---	---	---	---
Water, drift	---	---	---	---
Dermal exposures				
At 25 feet	0.0043	++	++	++
At 100 feet	0.0028	++	++	++
Dog petting	0.0003	++	++	++

Table F-3--Margins of safety for workers
Nursery: Humboldt
Pesticide: Glyphosate

	Exposure (mg/kg/day)	Margin of safety relative to: LD_{50} (4320.0)	Systemic NOEL (30.00)	Reproductive NOEL (10.00)
Average				
Applicator	0.0084	++	++	++
Weeder	---	---	---	---
Inventory	---	---	---	---
Lifting	---	---	---	---
Extreme				
Applicator	0.0186	++	++	540
Weeder	---	---	---	---
Inventory	---	---	---	---
Lifting	---	---	---	---
Accident spray	0.8300	++	36	12
Accident spill	180.0000	24	-6.0	-18
Premature reentry	---	---	---	---

Margins of Safety for Exposed Members of the Public

	Exposure (mg/kg/day)	Margin of safety relative to: LD_{50} (4320.0)	Systemic NOEL (30.00)	Reproductive NOEL (10.00)
Average over applications				
Dietary exposures				
Beef	0.0002	++	++	++
Rabbit	0.0034	++	++	++
Grouse	0.0028	++	++	++
Vegs., 25 feet	0.0094	++	++	++
Vegs., 100 feet	0.0064	++	++	++
Water, runoff	---	---	---	---
Water, drift	---	---	---	---
Dermal exposures				
At 25 feet	0.0029	++	++	++
At 100 feet	0.0018	++	++	++
Dog petting	0.0002	++	++	++
Lowest margins of safety				
Dietary exposures				
Beef	0.0002	++	++	++
Rabbit	0.0034	++	++	++
Grouse	0.0028	++	++	++
Vegs., 25 feet	0.0094	++	++	++
Vegs., 100 feet	0.0064	++	++	++
Water, runoff	---	---	---	---
Water, drift	---	---	---	---
Dermal exposures				
At 25 feet	0.0029	++	++	++
At 100 feet	0.0018	++	++	++
Dog petting	0.0002	++	++	++

Table F-4--Margins of safety for workers
Nursery: Humboldt
Pesticide: Oxyfluorfen

		Margin of safety relative to:		
	Exposure (mg/kg/day)	LD_{50} (5000.0)	Systemic NOEL (0.30)	Reproductive NOEL (0.50)
Average				
Applicator	0.0015	++	200	330
Weeder	0.0041	++	72	120
Inventory	0.0007	++	450	750
Lifting	0.0000	++	++	++
Extreme				
Applicator	0.0035	++	86	140
Weeder	0.0453	++	6.6	11
Inventory	0.0716	++	4.2	7.0
Lifting	0.0000	++	++	++
Accident spray	0.2100	++	1.4	2.4
Accident spill	120.0000	42	-400	-240
Premature reentry	0.0854	++	3.5	5.9

Margins of Safety for Exposed Members of the Public

		Margin of safety relative to:		
	Exposure (mg/kg/day)	LD_{50} (5000.0)	Systemic NOEL (0.30)	Reproductive NOEL (0.50)
Average over applications				
Dietary exposures				
Beef	0.0000	++	++	++
Rabbit	0.0009	++	350	580
Grouse	0.0007	++	430	710
Vegs., 25 feet	0.0023	++	130	220
Vegs., 100 feet	0.0016	++	190	310
Water, runoff	---	---	---	---
Water, drift	---	---	---	---
Dermal exposures				
At 25 feet	0.0007	++	420	690
At 100 feet	0.0005	++	650	++
Dog petting	0.0000	++	++	++
Lowest margins of safety				
Dietary exposures				
Beef	0.0000	++	++	++
Rabbit	0.0009	++	350	580
Grouse	0.0007	++	430	710
Vegs., 25 feet	0.0023	++	130	220
Vegs., 100 feet	0.0016	++	190	310
Water, runoff	---	---	---	---
Water, drift	---	---	---	---
Dermal exposures				
At 25 feet	0.0007	++	420	690
At 100 feet	0.0005	++	650	++
Dog petting	0.0000	++	++	++

Table F-5--Margins of safety for workers
Nursery: Humboldt
Pesticide: Benomyl

	Exposure (mg/kg/day)	Margin of safety relative to: LD_{50} (10000.0)	Systemic NOEL (12.50)	Reproductive NOEL (5.00)
Average				
Applicator	0.0015	++	++	++
Weeder	0.0583	++	210	86
Inventory	0.0180	++	690	280
Lifting	0.0009	++	++	++
Extreme				
Applicator	0.0035	++	++	++
Weeder	0.4638	++	27	11
Inventory	0.4638	++	27	11
Lifting	0.0583	++	210	86
Accident spray	1.3000	++	9.6	3.8
Accident spill	---	---	---	---
Premature reentry	0.1124	++	110	44

Margins of Safety for Exposed Members of the Public

	Exposure (mg/kg/day)	Margin of safety relative to: LD_{50} (10000.0)	Systemic NOEL (12.50)	Reproductive NOEL (5.00)
Average over applications				
Dietary exposures				
Beef	0.0001	++	++	++
Rabbit	0.0011	++	++	++
Grouse	0.0009	++	++	++
Vegs., 25 feet	0.0030	++	++	++
Vegs., 100 feet	0.0021	++	++	++
Water, runoff	---	---	---	---
Water, drift	---	---	---	---
Dermal exposures				
At 25 feet	0.0009	++	++	++
At 100 feet	0.0006	++	++	++
Dog petting	0.0001	++	++	++
Lowest margins of safety				
Dietary exposures				
Beef	0.0003	++	++	++
Rabbit	0.0052	++	++	960
Grouse	0.0042	++	++	++
Vegs., 25 feet	0.0140	++	890	360
Vegs., 100 feet	0.0097	++	++	520
Water, runoff	---	---	---	---
Water, drift	---	---	---	---
Dermal exposures				
At 25 feet	0.0043	++	++	++
At 100 feet	0.0028	++	++	++
Dog petting	0.0003	++	++	++

Table F-6--Margins of safety for workers
Nursery: Humboldt
Pesticide: Chlorothalonil

	Exposure (mg/kg/day)	Margin of safety relative to: LD_{50} (10000.0)	Systemic NOEL (1.50)	Reproductive NOEL (5.00)
Average				
Applicator	0.0044	++	340	++
Weeder	0.0072	++	210	690
Inventory	0.0164	++	91	300
Lifting	0.0096	++	160	520
Extreme				
Applicator	0.0105	++	140	480
Weeder	0.2312	++	6.5	22
Inventory	0.2312	++	6.5	22
Lifting	0.2890	++	5.2	17
Accident spray	0.6300	++	2.4	7.9
Accident spill	360.0000	28	-240	-72
Premature reentry	0.2569	++	5.8	19

Margins of Safety for Exposed Members of the Public

	Exposure (mg/kg/day)	Margin of safety relative to: LD_{50} (10000.0)	Systemic NOEL (1.50)	Reproductive NOEL (5.00)
Average over applications				
Dietary exposures				
Beef	0.0001	++	++	++
Rabbit	0.0026	++	580	++
Grouse	0.0021	++	710	++
Vegs., 25 feet	0.0070	++	210	710
Vegs., 100 feet	0.0048	++	310	1000
Water, runoff	---	---	---	---
Water, drift	---	---	---	---
Dermal exposures				
At 25 feet	0.0022	++	680	++
At 100 feet	0.0014	++	++	++
Dog petting	0.0001	++	++	++
Lowest margins of safety				
Dietary exposures				
Beef	0.0001	++	++	++
Rabbit	0.0026	++	580	++
Grouse	0.0021	++	710	++
Vegs., 25 feet	0.0070	++	210	710
Vegs., 100 feet	0.0048	++	310	1000
Water, runoff	---	---	---	---
Water, drift	---	---	---	---
Dermal exposures				
At 25 feet	0.0022	++	680	++
At 100 feet	0.0014	++	++	++
Dog petting	0.0001	++	++	++

Table F-7--Margins of safety for workers
Nursery: Humboldt
Pesticide: Triadimefon

	Exposure (mg/kg/day)	Margin of safety relative to: LD_{50} (363.0)	Systemic NOEL (2.50)	Reproductive NOEL (2.50)
Average				
Applicator	0.0001	++	++	++
Weeder	0.0460	++	54	54
Inventory	0.0175	++	140	140
Lifting	0.0004	++	++	++
Extreme				
Applicator	0.0002	++	++	++
Weeder	0.0781	++	32	32
Inventory	0.0328	++	76	76
Lifting	0.0005	++	++	++
Accident spray	0.2100	++	12	12
Accident spill	---	---	---	---
Premature reentry	0.0857	++	29	29

Margins of Safety for Exposed Members of the Public

	Exposure (mg/kg/day)	Margin of safety relative to: LD_{50} (363.0)	Systemic NOEL (2.50)	Reproductive NOEL (2.50)
Average over applications				
Dietary exposures				
Beef	0.0000	++	++	++
Rabbit	0.0009	++	++	++
Grouse	0.0007	++	++	++
Vegs., 25 feet	0.0023	++	++	++
Vegs., 100 feet	0.0016	++	++	++
Water, runoff	---	---	---	---
Water, drift	---	---	---	---
Dermal exposures				
At 25 feet	0.0007	++	++	++
At 100 feet	0.0005	++	++	++
Dog petting	0.0000	++	++	++
Lowest margins of safety				
Dietary exposures				
Beef	0.0000	++	++	++
Rabbit	0.0009	++	++	++
Grouse	0.0007	++	++	++
Vegs., 25 feet	0.0023	++	++	++
Vegs., 100 feet	0.0016	++	++	++
Water, runoff	---	---	---	---
Water, drift	---	---	---	---
Dermal exposures				
At 25 feet	0.0007	++	++	++
At 100 feet	0.0005	++	++	++
Dog petting	0.0000	++	++	++

Table F-8--Lifetime cancer risk for exposed members of the public
Nursery: Humboldt

	Oxyfluorfen	Glyphosate	Chlorothalonil	Benomyl
5 Exposures				
Rabbit	5.E-12	2.E-11	1.E-08	1.E-09
Vegs. (25 ft)	1.E-11	4.E-11	3.E-08	4.E-09
Water, drift	----	----	----	----
Dermal (25 ft)	4.E-12	1.E-11	1.E-08	1.E-09
30 Exposures				
Rabbit	3.E-11	1.E-10	7.E-08	9.E-09
Vegs. (25 ft)	8.E-11	3.E-10	2.E-07	2.E-08
Water, drift	----	----	----	----
Dermal (25 ft)	2.E-11	8.E-11	6.E-08	7.E-09

Table F-9--Lifetime cancer risk for workers
Nursery: Humboldt

	Oxyfluorfen	Glyphosate	Chlorothalonil	Benomyl
5 Years of exposure				
Weeding	9.E-10	----	7.E-07	2.E-06
Inventory	6.E-11	----	7.E-07	2.E-07
Lifting	1.E-12	----	7.E-07	2.E-08
Application	6.E-12	2.E-11	7.E-08	5.E-10
30 Years of exposure				
Weeding	5.E-09	----	4.E-06	9.E-06
Inventory	4.E-10	----	4.E-06	1.E-06
Lifting	6.E-12	----	4.E-06	1.E-07
Application	3.E-11	1.E-10	4.E-07	3.E-09

G. Lucky Peak Nursery

EXPOSURE ANALYSIS METHODS

The Lucky Peak Nursery is located in Idaho and has a total area of 298 acres and a total nursery bed area of 61 acres. Approximately 26 acres are treated with pesticides every year. The nursery generally employs the following number of personnel annually for its operations: 1 to 2 mixer/loader/applicators, 11 to 24 weeders, 7 to 8 inventory personnel, 60 to 95 lifters, 48 to 96 sorters and packers, 6 fumigators, and 4 tarp lifters.

The exposure analysis methods used to estimate doses to workers and the public in the Lucky Peak Nursery were similar to those described for the generic nursery, except that the conditions specific to the nursery, such as the pesticides used, the application rates, and the timing of the applications, were used in the analyses rather than the generic set of conditions. The pesticide application schedule for the nursery is given in table G-1. (Tables can be found at the end of this section.) For the purposes of determining foliar washoff of pesticide residues, each bed was assumed to be irrigated every other day at a rate of 0.1 inches per day. Dazomet or a mixture of methyl bromide and chloropicrin are applied to approximately 17.5 acres in September.

There are three Forest Service residences onsite and three residences within 100 feet. The land bordering the nursery is primarily rangeland.

The nearest live bodies of water are a reservoir and a stream approximately 350 feet and 100 feet, respectively, from the nursery. There is no aquifer below the nursery. The soil is heavy silt loam to sandy loam.

RISK ANALYSIS

Risk of Systemic and Reproductive Effects

Risks to members of the public and workers involved in pesticide applications and related nursery tasks in the Lucky Peak Nursery are based on the methods described in chapters 3 and 4 of the generic nursery risk assessment. Tables G-2 through G-4 present exposure levels and margins of safety based on LD_{50}'s, systemic NOEL's, and reproductive NOEL's for routine-realistic (average), routine-extreme, and accidental exposures.

The MOS tables for each chemical consist of two parts. The first lists worker exposures and MOS's for the chemical as it is used in the Lucky Peak Nursery. The worker portion lists MOS's for routine-realistic (average), routine-extreme (extreme), and accidental exposures (spraying, spills on the skin, and premature reentry). LD_{50}'s and NOEL's are listed above each column of MOS's.

The second portion of each table lists public exposures and MOS's via specific exposure routes for routine-realistic (average) and routine-extreme (lowest MOS's) exposures. The only accidents that may

affect the public are assumed to be those involving fumigant spills. The analysis of fumigant spills is contained in the generic nursery risk analysis.

Dashes in the worker portion of the tables indicate that the chemical is used only in cover crops. Dashes in the public portion indicate that the route of exposure is not considered a significant one in this analysis. Margins of safety greater than 1,000 are indicated by ++.

Where MOS's are greater than 100, risk can be considered negligible for the chemical in question. MOS's between 10 and 100 indicate a slight risk of low-level toxic effects--to sensitive individuals in particular. MOS's between 1 and 10 indicate a moderate risk of low-level toxic effects, especially in light of the uncertainty in extrapolating from laboratory test animal species to humans. Risk may be significant where an MOS for a chemical is negative (the estimated exposure exceeds the animal NOEL). Refer to the discussion of low-level toxic effects in the generic nursery risk analysis.

Cancer Risk

None of the chemicals used at the Lucky Peak Nursery is a known or suspected carcinogen; therefore, no cancer risk analysis was conducted.

Table G-1--Lucky Peak Nursery schedule for pesticide applications (based on average use)

Crop	Year	Chemical	Acres	Rate (lb/acre)	Applications per year	Month of application
Cover crop	0	Methyl Bromide + Chloropicrin	--	350.0	1	Sep
Pine	1	Bifenox	9.0	3.0	2	Apr, Jun
Pine	1	DCPA	4.0	10.5	2	May, Jul
Douglas-fir	1	Bifenox	0.2	3.0	2	Apr, Jun
Spruce	1	Diphenamid	0.3	6.0	1	Apr
Spruce	1	DCPA	1.2	10.5	2	May, Jul
Other conifers	1	Bifenox	3.3	3.0	2	Apr, Jun
Other conifers	1	Diphenamid	0.7	6.0	1	Apr
Other conifers	1	DCPA	0.7	10.5	2	May-Jun
Pine	2	Bifenox	8.2	3.0	2	Apr, Jun
Pine	2	DCPA	4.2	10.5	2	May, Jul
Douglas-fir	2	Bifenox	0.2	3.0	2	Apr, Jun
Spruce	2	DCPA	0.3	10.5	2	May, Jul
Other conifers	2	Bifenox	0.2	3.0	2	Apr, Jun
Spruce	3	DCPA	0.7	10.5	2	May-Jun

Table G-2--Margins of safety for workers
Nursery: Lucky Peak
Pesticide: Bifenox

	Exposure (mg/kg/day)	Margin of safety relative to: LD_{50} (6400.0)	Systemic NOEL (12.50)	Reproductive NOEL (10.00)
Average				
Applicator	0.0048	++	++	++
Weeder	0.0121	++	1000	820
Inventory	0.0243	++	520	410
Lifting	0.0000	++	++	++
Extreme				
Applicator	0.0126	++	1000	800
Weeder	0.2301	++	54	43
Inventory	0.4097	++	31	24
Lifting	0.0000	++	++	++
Accident spray	1.3000	++	9.6	7.7
Accident spill	120.0000	53	-9.6	-12
Premature reentry	0.5112	++	24	20

Margins of Safety for Exposed Members of the Public

	Exposure (mg/kg/day)	Margin of safety relative to: LD_{50} (6400.0)	Systemic NOEL (12.50)	Reproductive NOEL (10.00)
Average over applications				
Dietary exposures				
Beef	0.0002	++	++	++
Rabbit	0.0052	++	++	++
Grouse	0.0042	++	++	++
Vegs., 25 feet	0.0140	++	890	710
Vegs., 100 feet	0.0097	++	++	1000
Water, runoff	---	---	---	---
Water, drift	---	---	---	---
Dermal exposures				
At 25 feet	0.0043	++	++	++
At 100 feet	0.0028	++	++	++
Dog petting	0.0003	++	++	++
Lowest margins of safety				
Dietary exposures				
Beef	0.0002	++	++	++
Rabbit	0.0052	++	++	++
Grouse	0.0042	++	++	++
Vegs., 25 feet	0.0140	++	890	710
Vegs., 100 feet	0.0097	++	++	1000
Water, runoff	---	---	---	---
Water, drift	---	---	---	---
Dermal exposures				
At 25 feet	0.0043	++	++	++
At 100 feet	0.0028	++	++	++
Dog petting	0.0003	++	++	++

Table G-3--Margins of safety for workers
Nursery: Lucky Peak
Pesticide: DCPA

		Margin of safety relative to:		
	Exposure (mg/kg/day)	LD_{50} (10250.0)	Systemic NOEL (50.00)	Reproductive NOEL (50.00)
Average				
Applicator	0.0020	++	++	++
Weeder	0.3009	++	170	170
Inventory	0.2341	++	210	210
Lifting	0.0044	++	++	++
Extreme				
Applicator	0.0059	++	++	++
Weeder	1.2715	++	39	39
Inventory	1.2715	++	39	39
Lifting	0.0055	++	++	++
Accident spray	4.4000	++	11	11
Accident spill	360.0000	28	-7.2	-7.2
Premature reentry	1.7988	++	28	28

Margins of Safety for Exposed Members of the Public

		Margin of safety relative to:		
	Exposure (mg/kg/day)	LD_{50} (10250.0)	Systemic NOEL (50.00)	Reproductive NOEL (50.00)
Average over applications				
Dietary exposures				
Beef	0.0009	++	++	++
Rabbit	0.0180	++	++	++
Grouse	0.0150	++	++	++
Vegs., 25 feet	0.0490	++	1000	1000
Vegs., 100 feet	0.0340	++	++	++
Water, runoff	---	---	---	---
Water, drift	0.0000	++	++	++
Dermal exposures				
At 25 feet	0.0150	++	++	++
At 100 feet	0.0097	++	++	++
Dog petting	0.0010	++	++	++
Lowest margins of safety				
Dietary exposures				
Beef	0.0009	++	++	++
Rabbit	0.0180	++	++	++
Grouse	0.0150	++	++	++
Vegs., 25 feet	0.0490	++	1000	1000
Vegs., 100 feet	0.0340	++	++	++
Water, runoff	---	---	---	---
Water, drift	0.0000	++	++	++
Dermal exposures				
At 25 feet	0.0150	++	++	++
At 100 feet	0.0097	++	++	++
Dog petting	0.0010	++	++	++

Table G-4--Margins of safety for workers
Nursery: Lucky Peak
Pesticide: Diphenamid

		Margin of safety relative to:		
	Exposure (mg/kg/day)	LD_{50} (1373.0)	Systemic NOEL (3.00)	Reproductive NOEL (10.00)
Average				
Applicator	0.0009	++	++	++
Weeder	0.0269	++	110	370
Inventory	0.0032	++	940	++
Lifting	0.0000	++	++	++
Extreme				
Applicator	0.0020	++	++	++
Weeder	0.4711	++	6.4	21
Inventory	0.4711	++	6.4	21
Lifting	0.0000	++	++	++
Accident spray	2.5000	550	1.2	4.0
Accident spill	---	---	---	---
Premature reentry	1.0226	++	2.9	9.8

Margins of Safety for Exposed Members of the Public

		Margin of safety relative to:		
	Exposure (mg/kg/day)	LD_{50} (1373.0)	Systemic NOEL (3.00)	Reproductive NOEL (10.00)
Average over applications				
Dietary exposures				
Beef	0.0004	++	++	++
Rabbit	0.0100	++	300	1000
Grouse	0.0084	++	360	++
Vegs., 25 feet	0.0280	++	110	360
Vegs., 100 feet	0.0190	++	160	530
Water, runoff	---	---	---	---
Water, drift	0.0000	++	++	++
Dermal exposures				
At 25 feet	0.0087	++	340	++
At 100 feet	0.0055	++	550	++
Dog petting	0.0006	++	++	++
Lowest margins of safety				
Dietary exposures				
Beef	0.0004	++	++	++
Rabbit	0.0100	++	300	1000
Grouse	0.0084	++	360	++
Vegs., 25 feet	0.0280	++	110	360
Vegs., 100 feet	0.0190	++	160	530
Water, runoff	---	---	---	---
Water, drift	0.0000	++	++	++
Dermal exposures				
At 25 feet	0.0087	++	340	++
At 100 feet	0.0055	++	550	++
Dog petting	0.0006	++	++	++

H. Placerville Nursery

EXPOSURE ANALYSIS METHODS

The Placerville Nursery is located in California and has a total area of 157 acres and a total nursery bed area of 97 acres. Approximately 100 acres are treated with pesticides every year. The nursery generally employs the following number of personnel annually for its operations: 1 to 3 mixer/loader/applicators, 11 to 24 weeders, 8 inventory personnel, 20 to 30 lifters, 43 to 52 sorters and packers, 4 fumigators, and 3 to 4 tarp lifters.

The exposure analysis methods used to estimate doses to workers and the public in the Placerville Nursery were similar to those described for the generic nursery, except that the conditions specific to the nursery, such as the pesticides used, the application rates, and the timing of the applications, were used in the analyses rather than the generic set of conditions. The pesticide application schedule for the nursery is shown in table H-1. (Tables can be found at the end of this section.) For the purposes of determining foliar washoff of pesticide residues, each bed was assumed to be irrigated every other day at a rate of 0.1 to 0.4 inches per day. Methyl bromide and chloropicrin are applied to approximately 26 acres in July. From January to March, approximately 3,400 pounds of seed are treated with captan, and in April and May, approximately 3,700 pounds of seed are treated with thiram.

There are no Forest Service residences onsite, but there are four residences within 100 feet of the nursery boundary. The land bordering the nursery is predominantly residential, with some orchards and farms.

The nearest live water is a spring 600 feet from the nursery. There is no aquifer below the nursery. The soil is Aiken clay loam.

RISK ANALYSIS

Risk of Systemic and Reproductive Effects

Risks to members of the public and workers involved in pesticide applications and related nursery tasks in the Placerville Nursery are based on the methods described in chapters 3 and 4 of the generic nursery risk assessment. Tables H-2 through H-6 present exposure levels and margins of safety based on LD_{50}'s, systemic NOEL's, and reproductive NOEL's for routine-realistic (average), routine-extreme, and accidental exposures.

The MOS tables for each chemical consist of two parts. The first lists worker exposures and MOS's for the chemical as it is used in the Placerville Nursery. The worker portion lists MOS's for routine-realistic (average), routine-extreme (extreme), and accidental exposures (spraying, spills on the skin, and premature reentry). LD_{50}'s and NOEL's are listed above each column of MOS's.

The second portion of each table lists public exposures and MOS's via specific exposure routes for routine-realistic (average) and routine-extreme (lowest MOS's) exposures. The only accidents that may affect the public are assumed to be those involving fumigant spills. The analysis of fumigant spills is contained in the generic nursery risk analysis.

Dashes in the worker portion of the tables indicate that the chemical is used only in cover crops. Dashes in the public portion indicate that the route of exposure is not considered a significant one in this analysis. Margins of safety greater than 1,000 are indicated by ++.

Where MOS's are greater than 100, risk can be considered negligible for the chemical in question. MOS's between 10 and 100 indicate a slight risk of low-level toxic effects--to sensitive individuals in particular. MOS's between 1 and 10 indicate a moderate risk of low-level toxic effects, especially in light of the uncertainty in extrapolating from laboratory test animal species to humans. Risk may be significant where an MOS for a chemical is negative (the estimated exposure exceeds the animal NOEL). Refer to the discussion of low-level toxic effects in the generic nursery risk analysis.

Cancer Risk

Lifetime cancer risks for the known or suspected carcinogenic chemicals glyphosate, benomyl, and captan to members of the public at the Placerville Nursery are listed in table H-7 for different exposure routes and numbers of lifetime exposures. Lifetime cancer risk to workers from the use of those chemicals in various nursery tasks are listed in table H-8. The cancer risk tables should be interpreted as follows. Where the exponent is lower, the risk is higher. For example, a risk value of 1.0E-06 (1 chance in 1 million) is lower than a risk of 1.0E-05 (1 chance in 100,000). A risk of 7.0E-06 exceeds a risk of 1.0E-06.

In general, risk may be considered acceptable where risk to an individual is equal to or lower than 1 in 1 million. Where risk exceeds 1 chance in 100,000, proper precautions that reduce exposure levels may, in turn, reduce the cancer risk to acceptable levels.

Table H-1--Placerville Nursery schedule for pesticide applications (based on average use)

Crop	Year	Chemical	Acres	Rate (lb/acre)	Applications per year	Month of application
Cover crop	0	Glyphosate	28	2.0	1	Feb
Pine	1	Bifenox	9.3	3.0	2	May, Jul
Pine	1	Diphenamid	9.3	4.0	2	Jun, Aug
Pine	1	Benomyl	1-2	6.5	1	Jun
Pine	1	Captan	1-2	30.0	2	May, Jul
Douglas-fir	1	Bifenox	9.3	3.0	2	May, Jul
Douglas-fir	1	Diphenamid	9.3	4.0	2	Jun, Aug
Other conifers	1	Bifenox	9.4	3.0	2	May, Jul
Other conifers	1	Diphenamid	9.4	4.0	2	Jun, Aug
Pine	2	Bifenox	4.7	3.0	2	Mar, May
Pine	2	Diphenamid	4.7	4.0	2	Mar, May
Douglas-fir	2	Bifenox	4.7	3.0	2	Mar, May
Douglas-fir	2	Diphenamid	4.7	4.0	2	Apr, Jun
Other conifers	2	Bifenox	4.6	3.0	2	Mar, May
Other conifers	2	Diphenamid	4.6	4.0	2	Apr, Jun
Seed treatment		Captan		1 tsp/gal water		Before sowing
Seed treatment		Thiram				Before sowing

Table H-2--Margins of safety for workers
Nursery: Placerville
Pesticide: Bifenox

		Margin of safety relative to:		
	Exposure (mg/kg/day)	LD_{50} (6400.0)	Systemic NOEL (12.50)	Reproductive NOEL (10.00)
Average				
Applicator	0.0049	++	++	++
Weeder	0.0100	++	++	1000
Inventory	0.0208	++	600	480
Lifting	0.0000	++	++	++
Extreme				
Applicator	0.0131	++	950	760
Weeder	0.2201	++	57	45
Inventory	0.4045	++	31	25
Lifting	0.0000	++	++	++
Accident spray	1.3000	++	9.6	7.7
Accident spill	120.0000	53	-9.6	-12
Premature reentry	0.5109	++	24	20

Margins of Safety for Exposed Members of the Public

		Margin of safety relative to:		
	Exposure (mg/kg/day)	LD_{50} (6400.0)	Systemic NOEL (12.50)	Reproductive NOEL (10.00)
Average over applications				
Dietary exposures				
Beef	0.0002	++	++	++
Rabbit	0.0052	++	++	++
Grouse	0.0042	++	++	++
Vegs., 25 feet	0.0140	++	890	710
Vegs., 100 feet	0.0097	++	++	1000
Water, runoff	---	---	---	---
Water, drift	---	---	---	---
Dermal exposures				
At 25 feet	0.0043	++	++	++
At 100 feet	0.0028	++	++	++
Dog petting	0.0003	++	++	++
Lowest margins of safety				
Dietary exposures				
Beef	0.0002	++	++	++
Rabbit	0.0052	++	++	++
Grouse	0.0042	++	++	++
Vegs., 25 feet	0.0140	++	890	710
Vegs., 100 feet	0.0097	++	++	1000
Water, runoff	---	---	---	---
Water, drift	---	---	---	---
Dermal exposures				
At 25 feet	0.0043	++	++	++
At 100 feet	0.0028	++	++	++
Dog petting	0.0003	++	++	++

Table H-3--Margins of safety for workers
Nursery: Placerville
Pesticide: Diphenamid

		Margin of safety relative to:		
	Exposure (mg/kg/day)	LD_{50} (1373.0)	Systemic NOEL (3.00)	Reproductive NOEL (10.00)
Average				
Applicator	0.0065	++	460	++
Weeder	0.0148	++	200	680
Inventory	0.0016	++	++	++
Lifting	0.0000	++	++	++
Extreme				
Applicator	0.0175	++	170	570
Weeder	0.3004	++	10.0	33
Inventory	0.3004	++	10.0	33
Lifting	0.0000	++	++	++
Accident spray	1.7000	810	1.8	5.9
Accident spill	---	---	---	---
Premature reentry	0.6814	++	4.4	15

Margins of Safety for Exposed Members of the Public

		Margin of safety relative to:		
	Exposure (mg/kg/day)	LD_{50} (1373.0)	Systemic NOEL (3.00)	Reproductive NOEL (10.00)
Average over applications				
Dietary exposures				
Beef	0.0003	++	++	++
Rabbit	0.0069	++	430	++
Grouse	0.0056	++	540	++
Vegs., 25 feet	0.0190	++	160	530
Vegs., 100 feet	0.0130	++	230	770
Water, runoff	---	---	---	---
Water, drift	---	---	---	---
Dermal exposures				
At 25 feet	0.0058	++	520	++
At 100 feet	0.0037	++	810	++
Dog petting	0.0004	++	++	++
Lowest margins of safety				
Dietary exposures				
Beef	0.0003	++	++	++
Rabbit	0.0069	++	430	++
Grouse	0.0056	++	540	++
Vegs., 25 feet	0.0190	++	160	530
Vegs., 100 feet	0.0130	++	230	770
Water, runoff	---	---	---	---
Water, drift	---	---	---	---
Dermal exposures				
At 25 feet	0.0058	++	520	++
At 100 feet	0.0037	++	810	++
Dog petting	0.0004	++	++	++

Table H-4--Margins of safety for workers
Nursery: Placerville
Pesticide: Glyphosate

	Exposure (mg/kg/day)	Margin of safety relative to: LD_{50} (4320.0)	Systemic NOEL (30.00)	Reproductive NOEL (10.00)
Average				
Applicator	0.0117	++	++	850
Weeder	---	---	---	---
Inventory	---	---	---	---
Lifting	---	---	---	---
Extreme				
Applicator	0.0260	++	++	380
Weeder	---	---	---	---
Inventory	---	---	---	---
Lifting	---	---	---	---
Accident spray	0.8300	++	36	12
Accident spill	180.0000	24	-6.0	-18
Premature reentry	---	---	---	---

Margins of Safety for Exposed Members of the Public

	Exposure (mg/kg/day)	Margin of safety relative to: LD_{50} (4320.0)	Systemic NOEL (30.00)	Reproductive NOEL (10.00)
Average over applications				
Dietary exposures				
Beef	0.0002	++	++	++
Rabbit	0.0034	++	++	++
Grouse	0.0028	++	++	++
Vegs., 25 feet	0.0094	++	++	++
Vegs., 100 feet	0.0064	++	++	++
Water, runoff	---	---	---	---
Water, drift	---	---	---	---
Dermal exposures				
At 25 feet	0.0029	++	++	++
At 100 feet	0.0018	++	++	++
Dog petting	0.0002	++	++	++
Lowest margins of safety				
Dietary exposures				
Beef	0.0002	++	++	++
Rabbit	0.0034	++	++	++
Grouse	0.0028	++	++	++
Vegs., 25 feet	0.0094	++	++	++
Vegs., 100 feet	0.0064	++	++	++
Water, runoff	---	---	---	---
Water, drift	---	---	---	---
Dermal exposures				
At 25 feet	0.0029	++	++	++
At 100 feet	0.0018	++	++	++
Dog petting	0.0002	++	++	++

Table H-5--Margins of safety for workers
Nursery: Placerville
Pesticide: Benomyl

	Exposure (mg/kg/day)	Margin of safety relative to: LD_{50} (10000.0)	Systemic NOEL (12.50)	Reproductive NOEL (5.00)
Average				
Applicator	0.0020	++	++	++
Weeder	0.5770	++	22	8.7
Inventory	0.1782	++	70	28
Lifting	0.0091	++	++	550
Extreme				
Applicator	0.0045	++	++	++
Weeder	1.0049	++	12	5.0
Inventory	1.0049	++	12	5.0
Lifting	0.1264	++	99	40
Accident spray	2.7000	++	4.6	1.9
Accident spill	---	---	---	---
Premature reentry	1.1132	++	11	4.5

Margins of Safety for Exposed Members of the Public

	Exposure (mg/kg/day)	Margin of safety relative to: LD_{50} (10000.0)	Systemic NOEL (12.50)	Reproductive NOEL (5.00)
Average over applications				
Dietary exposures				
Beef	0.0006	++	++	++
Rabbit	0.0110	++	++	450
Grouse	0.0091	++	++	550
Vegs., 25 feet	0.0300	++	420	170
Vegs., 100 feet	0.0210	++	600	240
Water, runoff	---	---	---	---
Water, drift	---	---	---	---
Dermal exposures				
At 25 feet	0.0094	++	++	530
At 100 feet	0.0060	++	++	830
Dog petting	0.0006	++	++	++
Lowest margins of safety				
Dietary exposures				
Beef	0.0006	++	++	++
Rabbit	0.0110	++	++	450
Grouse	0.0091	++	++	550
Vegs., 25 feet	0.0300	++	420	170
Vegs., 100 feet	0.0210	++	600	240
Water, runoff	---	---	---	---
Water, drift	---	---	---	---
Dermal exposures				
At 25 feet	0.0094	++	++	530
At 100 feet	0.0060	++	++	830
Dog petting	0.0006	++	++	++

Table H-6--Margins of safety for workers
Nursery: Placerville
Pesticide: Captan

		Margin of safety relative to:		
	Exposure (mg/kg/day)	LD_{50} (9000.0)	Systemic NOEL (25.00)	Reproductive NOEL (12.50)
Average				
Applicator	0.0094	++	++	++
Weeder	2.1339	++	12	5.9
Inventory	0.6486	++	39	19
Lifting	0.0002	++	++	++
Extreme				
Applicator	0.0209	++	++	600
Weeder	4.3535	++	5.7	2.9
Inventory	2.8452	++	8.8	4.4
Lifting	0.0031	++	++	++
Accident spray	13.0000	690	1.9	-1.0
Accident spill	240.0000	38	-9.6	-19
Premature reentry	5.1245	++	4.9	2.4

Margins of Safety for Exposed Members of the Public

		Margin of safety relative to:		
	Exposure (mg/kg/day)	LD_{50} (9000.0)	Systemic NOEL (25.00)	Reproductive NOEL (12.50)
Average over applications				
Dietary exposures				
Beef	0.0024	++	++	++
Rabbit	0.0520	++	480	240
Grouse	0.0420	++	600	300
Vegs., 25 feet	0.1400	++	180	89
Vegs., 100 feet	0.0970	++	260	130
Water, runoff	---	---	---	---
Water, drift	---	---	---	---
Dermal exposures				
At 25 feet	0.0430	++	580	290
At 100 feet	0.0280	++	890	450
Dog petting	0.0028	++	++	++
Lowest margins of safety				
Dietary exposures				
Beef	0.0024	++	++	++
Rabbit	0.0520	++	480	240
Grouse	0.0420	++	600	300
Vegs., 25 feet	0.1400	++	180	89
Vegs., 100 feet	0.0970	++	260	130
Water, runoff	---	---	---	---
Water, drift	---	---	---	---
Dermal exposures				
At 25 feet	0.0430	++	580	290
At 100 feet	0.0280	++	890	450
Dog petting	0.0028	++	++	++

Table H-7--Lifetime cancer risk for exposed members of the public
Nursery: Placerville

	Glyphosate	Benomyl	Captan
5 Exposures			
Rabbit	2.E-11	1.E-08	6.E-08
Vegs. (25 ft)	4.E-11	4.E-08	1.E-07
Water, drift	----	----	----
Dermal (25 ft)	1.E-11	1.E-08	5.E-08
30 Exposures			
Rabbit	1.E-10	9.E-08	3.E-07
Vegs. (25 ft)	3.E-10	2.E-07	9.E-07
Water, drift	----	----	----
Dermal (25 ft)	8.E-11	7.E-08	3.E-07

Table H-8--Lifetime cancer risk for workers
Nursery: Placerville

	Glyphosate	Benomyl	Captan
5 Years of exposure			
Weeding	----	1.E-06	4.E-06
Inventory	----	2.E-07	5.E-07
Lifting	----	1.E-08	2.E-10
Application	3.E-11	7.E-11	5.E-10
30 Years of exposure			
Weeding	----	7.E-06	2.E-05
Inventory	----	9.E-07	3.E-06
Lifting	----	8.E-08	1.E-09
Application	2.E-10	4.E-10	3.E-09

I. Stone Nursery

EXPOSURE ANALYSIS METHODS

The Stone Nursery, located in Oregon, has a total area of 306 acres and a total nursery bed area of 220 acres. All 220 acres of beds are treated with pesticides every year. The nursery generally employs the following number of personnel annually for its operations: 4 mixer/loader/applicators, 11 to 24 contract weeders, 24 to 30 inventory personnel, 20 to 22 contract lifters, 170 to 190 sorters and packers, 5 to 7 contract fumigators, and 3 to 4 contract tarp lifters.

The exposure analysis methods used to estimate doses to workers and the public in the Stone Nursery were similar to those described for the generic nursery, except that conditions specific to the nursery, such as the pesticides used, the application rates, and the timing of the applications, were used in the analyses rather than the generic set of conditions. The pesticide application schedule for the nursery is shown in table I-1. (Tables can be found at the end of this section.) For the purposes of determining foliar washoff of pesticide residues, each bed was assumed to be irrigated every other day at a rate of 0.12 to 0.25 inches per day. Methyl bromide and chloropicrin are applied to approximately 40 to 75 acres in September. Dazomet is applied to approximately 20 acres, also in September.

There are no Forest Service residences onsite, but there are 9 residences within 100 feet of the nursery boundary. The land bordering the nursery is primarily farmland, with a much lesser amount residential.

The nearest live water is a creek approximately 25 feet from the nursery. There is no aquifer located below the nursery. The nursery soil is predominantly sandy loam.

RISK ANALYSIS

Risk of Systemic and Reproductive Effects

Risks to members of the public and workers involved in pesticide applications and related nursery tasks in the Stone Nursery are based on the methods described in chapters 3 and 4 of the generic nursery risk assessment. Tables I-2 through I-9 present exposure levels and margins of safety based on LD_{50}'s, systemic NOEL's, and reproductive NOEL's for routine-realistic (average), routine-extreme, and accidental exposures.

The MOS tables for each chemical consist of two parts. The first lists worker exposures and MOS's for the chemical as it is used in the Stone Nursery. The worker portion lists MOS's for routine-realistic (average), routine-extreme (extreme), and accidental exposures (spraying, spills on the skin, and premature reentry). LD_{50}'s and NOEL's are listed above each column of MOS's.

The second portion of each table lists public exposures and MOS's via specific exposure routes for routine-realistic (average) and routine-extreme (lowest MOS's) exposures. The only accidents that may affect the public are assumed to be those involving fumigant spills. The analysis of fumigant spills is contained in the generic nursery risk analysis.

Dashes in the worker portion of the tables indicate that the chemical is used only in cover crops. Dashes in the public portion indicate that the route of exposure is not considered a significant one in this analysis. Margins of safety greater than 1,000 are indicated by ++.

Where MOS's are greater than 100, risk can be considered negligible for the chemical in question. MOS's between 10 and 100 indicate a slight risk of low-level toxic effects--to sensitive individuals in particular. MOS's between 1 and 10 indicate a moderate risk of low-level toxic effects, especially in light of the uncertainty in extrapolating from laboratory test animal species to humans. Risk may be significant where an MOS for a chemical is negative (the estimated exposure exceeds the animal NOEL). Refer to the discussion of low-level toxic effects in the generic nursery risk analysis.

Cancer Risk

Lifetime cancer risks for oxyfluorfen to members of the public at the Stone Nursery are listed in table I-10 for different exposure routes and numbers of lifetime exposures. Lifetime cancer risk to workers from the use of oxyfluorfen in various nursery tasks is listed in table I-11. The cancer risk tables should be interpreted as follows. Where the exponent is lower, the risk is higher. For example, a risk value of 1.0E-06 (1 chance in 1 million) is lower than a risk of 1.0E-05 (1 chance in 100,000). A risk of 7.0E-06 exceeds a risk of 1.0E-06.

In general, risk may be considered acceptable where risk to an individual is equal to or lower than 1 in 1 million. Where risk exceeds 1 chance in 100,000, proper precautions that reduce exposure levels may, in turn, reduce the cancer risk to acceptable levels.

Table I-1--Stone Nursery schedule for pesticide applications
(based on average use)

Crop	Year	Chemical	Acres	Rate (lb/acre)	Applications per year	Month of application
Cover crop	0	Dicamba	0-110	0.5	1	Apr
Cover crop	0	Oxyfluorfen	40-75	0.5	1	Nov
Pine	1	Oxyfluorfen	11-22	0.5	1	Apr
Pine	1	Bifenox	11-22	3.0	4	Jun-Aug, Sep-Oct
Pine	1	Diphenamid	0.5-2.25	4.0	6	Apr, Jun-Aug, Sep-Oct, Dec
Pine	1	Fenvalerate	2	0.1	5	Jun-Sep
Douglas-fir	1	Oxyfluorfen	15-40	0.5	1	Apr
Douglas-fir	1	Bifenox	15-40	3.0	4	Jun-Aug, Sep-Oct
Douglas-fir	1	Fenvalerate	5	0.1	5	Jun-Sep
Spruce	1	Oxyfluorfen	1-2	0.5	1	Apr
Spruce	1	Diphenamid	1-2	2.2	6	Apr, Jun-Jul, Sep-Oct, Dec
Other conifers	1	Oxyfluorfen	0-3	0.5	1	Apr
Other conifers	1	Bifenox	3-10	3.0	4	Jun-Jul, Sep-Oct
Other conifers	1	Diphenamid	3-10	2.2	6	Apr, Jun-Jul, Sep-Oct, Dec
Other conifers	1	Fenvalerate	5	0.1	5	Jun-Sep
Other conifers	1	DCNA	5	1.0	2	May-Jul
Pine	2	Oxyfluorfen	11-22	0.5	2	Mar, Sep
Pine	2	Metalaxyl	5	8.0	1	Jun-Sep
Pine	2	Fenvalerate	15	0.1	2	Jun-Jul
Pine	2	Bifenox	11-22	0.5	4	May-Sep
Douglas-fir	2	Oxyfluorfen	15-40	2.2	2	Mar, Sep
Douglas-fir	2	Chlorpyrifos	30	1.0	1	Aug
Douglas-fir	2	Metalaxyl	10	1.2	1	Mar-Oct
Douglas-fir	2	Fenvalerate	30	0.1	2	Jun-Jul
Douglas-fir	2	DCNA	30	1.0	3	May-Dec
Douglas-fir	2	Bifenox	15-40	3.0	4	May-Sep
Spruce	2	Oxyfluorfen	3-5	0.5	2	Mar, Sep
Other conifers	2	Oxyfluorfen	17-32	0.5	2	Mar, Sep
Other conifers	2	Chlorpyrifos	5	1.0	1	Aug
Other conifers	2	Metalaxyl	5	1.2	2	Mar-Oct
Other conifers	2	Fenvalerate	5	0.1	2	Jun-Jul
Pine	3	Bifenox	0.5	3.0	4	May-Sep
Pine	3	Diphenamid	0-5	2.2	6	Mar, May-Jun, Aug-Sep, Nov
Douglas-fir	3	Bifenox	0-5	3.0	4	May-Jun, Aug-Sep
Spruce	3	Diphenamid	0.7-1.4	2.2	6	Mar, May-Jun, Aug-Sep, Nov
Other conifers	3	Bifenox	0-2	3.0	4	May-Jun, Aug-Sep
Other conifers	3	Diphenamid	0-2	2.2	6	Mar, May-Jun, Aug-Sep, Nov

Table I-2--Margins of safety for workers
Nursery: Stone
Pesticide: Bifenox

	Exposure (mg/kg/day)	Margin of safety relative to: LD_{50} (6400.0)	Systemic NOEL (12.50)	Reproductive NOEL (10.00)
Average				
Applicator	0.0121	++	1000	830
Weeder	0.0113	++	++	890
Inventory	0.0222	++	560	450
Lifting	0.0000	++	++	++
Extreme				
Applicator	0.0391	++	320	260
Weeder	0.2342	++	53	43
Inventory	0.4118	++	30	24
Lifting	0.0000	++	++	++
Accident spray	1.3000	++	9.6	7.7
Accident spill	120.0000	53	-9.6	-12
Premature reentry	0.4403	++	28	23

Margins of Safety for Exposed Members of the Public

	Exposure (mg/kg/day)	Margin of safety relative to: LD_{50} (6400.0)	Systemic NOEL (12.50)	Reproductive NOEL (10.00)
Average over applications				
Dietary exposures				
Beef	0.0002	++	++	++
Rabbit	0.0045	++	++	++
Grouse	0.0036	++	++	++
Vegs., 25 feet	0.0121	++	1000	830
Vegs., 100 feet	0.0083	++	++	++
Water, runoff	0.0004	++	++	++
Water, drift	0.0000	++	++	++
Dermal exposures				
At 25 feet	0.0037	++	++	++
At 100 feet	0.0024	++	++	++
Dog petting	0.0002	++	++	++
Lowest margins of safety				
Dietary exposures				
Beef	0.0002	++	++	++
Rabbit	0.0052	++	++	++
Grouse	0.0042	++	++	++
Vegs., 25 feet	0.0140	++	890	710
Vegs., 100 feet	0.0097	++	++	1000
Water, runoff	0.0004	++	++	++
Water, drift	0.0000	++	++	++
Dermal exposures				
At 25 feet	0.0043	++	++	++
At 100 feet	0.0028	++	++	++
Dog petting	0.0003	++	++	++

Table I-3--Margins of safety for workers
Nursery: Stone
Pesticide: Dicamba

		Margin of safety relative to:		
	Exposure (mg/kg/day)	LD_{50} (757.0)	Systemic NOEL (25.00)	Reproductive NOEL (2.50)
Average				
Applicator	0.0078	++	++	320
Weeder	---	---	---	---
Inventory	---	---	---	---
Lifting	---	---	---	---
Extreme				
Applicator	0.0174	++	++	140
Weeder	---	---	---	---
Inventory	---	---	---	---
Lifting	---	---	---	---
Accident spray	0.2100	++	120	12
Accident spill	240.0000	3.2	-9.6	-96
Premature reentry	---	---	---	---

Margins of Safety for Exposed Members of the Public

		Margin of safety relative to:		
	Exposure (mg/kg/day)	LD_{50} (757.0)	Systemic NOEL (25.00)	Reproductive NOEL (2.50)
Average over applications				
Dietary exposures				
Beef	0.0000	++	++	++
Rabbit	0.0009	++	++	++
Grouse	0.0007	++	++	++
Vegs., 25 feet	0.0023	++	++	++
Vegs., 100 feet	0.0016	++	++	++
Water, runoff	0.0002	++	++	++
Water, drift	0.0001	++	++	++
Dermal exposures				
At 25 feet	0.0007	++	++	++
At 100 feet	0.0005	++	++	++
Dog petting	0.0000	++	++	++
Lowest margins of safety				
Dietary exposures				
Beef	0.0000	++	++	++
Rabbit	0.0009	++	++	++
Grouse	0.0007	++	++	++
Vegs., 25 feet	0.0023	++	++	++
Vegs., 100 feet	0.0016	++	++	++
Water, runoff	0.0002	++	++	++
Water, drift	0.0001	++	++	++
Dermal exposures				
At 25 feet	0.0007	++	++	++
At 100 feet	0.0005	++	++	++
Dog petting	0.0000	++	++	++

Table I-4--Margins of safety for workers
Nursery: Stone
Pesticide: Diphenamid

	Exposure (mg/kg/day)	Margin of safety relative to: LD_{50} (1373.0)	Systemic NOEL (3.00)	Reproductive NOEL (10.00)
Average				
Applicator	0.0019	++	++	++
Weeder	0.0115	++	260	870
Inventory	0.0014	++	++	++
Lifting	0.0000	++	++	++
Extreme				
Applicator	0.0067	++	450	++
Weeder	0.3197	++	9.4	31
Inventory	0.3197	++	9.4	31
Lifting	0.0000	++	++	++
Accident spray	1.7000	810	1.8	5.9
Accident spill	---	---	---	---
Premature reentry	0.4058	++	7.4	25

Margins of Safety for Exposed Members of the Public

	Exposure (mg/kg/day)	Margin of safety relative to: LD_{50} (1373.0)	Systemic NOEL (3.00)	Reproductive NOEL (10.00)
Average over applications				
Dietary exposures				
Beef	0.0002	++	++	++
Rabbit	0.0041	++	730	++
Grouse	0.0034	++	900	++
Vegs., 25 feet	0.0109	++	280	920
Vegs., 100 feet	0.0077	++	390	++
Water, runoff	0.0002	++	++	++
Water, drift	0.0001	++	++	++
Dermal exposures				
At 25 feet	0.0035	++	870	++
At 100 feet	0.0022	++	++	++
Dog petting	0.0002	++	++	++
Lowest margins of safety				
Dietary exposures				
Beef	0.0003	++	++	++
Rabbit	0.0069	++	430	++
Grouse	0.0056	++	540	++
Vegs., 25 feet	0.0190	++	160	530
Vegs., 100 feet	0.0130	++	230	770
Water, runoff	0.0004	++	++	++
Water, drift	0.0001	++	++	++
Dermal exposures				
At 25 feet	0.0058	++	520	++
At 100 feet	0.0037	++	810	++
Dog petting	0.0004	++	++	++

Table I-5--Margins of safety for workers
Nursery: Stone
Pesticide: Oxyfluorfen

		Margin of safety relative to:		
	Exposure (mg/kg/day)	LD_{50} (5000.0)	Systemic NOEL (0.30)	Reproductive NOEL (0.50)
Average				
Applicator	0.0061	++	49	81
Weeder	0.0106	++	28	47
Inventory	0.0020	++	150	250
Lifting	0.0000	++	++	++
Extreme				
Applicator	0.0281	++	11	18
Weeder	0.2123	++	1.4	2.4
Inventory	0.3208	++	-1.1	1.6
Lifting	0.0003	++	++	++
Accident spray	0.9200	++	-3.1	-1.8
Accident spill	120.0000	42	-400	-240
Premature reentry	0.1678	++	1.8	3.0

Margins of Safety for Exposed Members of the Public

		Margin of safety relative to:		
	Exposure (mg/kg/day)	LD_{50} (5000.0)	Systemic NOEL (0.30)	Reproductive NOEL (0.50)
Average over applications				
Dietary exposures				
Beef	0.0001	++	++	++
Rabbit	0.0019	++	160	260
Grouse	0.0015	++	190	320
Vegs., 25 feet	0.0050	++	60	100
Vegs., 100 feet	0.0035	++	85	140
Water, runoff	0.0001	++	++	++
Water, drift	0.0000	++	++	++
Dermal exposures				
At 25 feet	0.0016	++	190	310
At 100 feet	0.0010	++	300	500
Dog petting	0.0001	++	++	++
Lowest margins of safety				
Dietary exposures				
Beef	0.0002	++	++	++
Rabbit	0.0038	++	79	130
Grouse	0.0031	++	97	160
Vegs., 25 feet	0.0100	++	30	50
Vegs., 100 feet	0.0071	++	42	70
Water, runoff	0.0002	++	++	++
Water, drift	0.0000	++	++	++
Dermal exposures				
At 25 feet	0.0032	++	94	160
At 100 feet	0.0020	++	150	250
Dog petting	0.0002	++	++	++

Table I-6--Margins of safety for workers
Nursery: Stone
Pesticide: DCNA

	Exposure (mg/kg/day)	Margin of safety relative to: LD_{50} (10000.0)	Systemic NOEL (2.50)	Reproductive NOEL (5.00)
Average				
Applicator	0.0057	++	430	870
Weeder	0.0275	++	91	180
Inventory	0.0275	++	91	180
Lifting	0.0000	++	++	++
Extreme				
Applicator	0.0140	++	180	360
Weeder	0.1106	++	23	45
Inventory	0.1106	++	23	45
Lifting	0.0000	++	++	++
Accident spray	0.4200	++	6.0	12
Accident spill	---	---	---	---
Premature reentry	0.1689	++	15	30

Margins of Safety for Exposed Members of the Public

	Exposure (mg/kg/day)	Margin of safety relative to: LD_{50} (10000.0)	Systemic NOEL (2.50)	Reproductive NOEL (5.00)
Average over applications				
Dietary exposures				
Beef	0.0001	++	++	++
Rabbit	0.0017	++	++	++
Grouse	0.0014	++	++	++
Vegs., 25 feet	0.0047	++	530	++
Vegs., 100 feet	0.0032	++	780	++
Water, runoff	0.0001	++	++	++
Water, drift	0.0000	++	++	++
Dermal exposures				
At 25 feet	0.0014	++	++	++
At 100 feet	0.0009	++	++	++
Dog petting	0.0001	++	++	++
Lowest margins of safety				
Dietary exposures				
Beef	0.0001	++	++	++
Rabbit	0.0017	++	++	++
Grouse	0.0014	++	++	++
Vegs., 25 feet	0.0047	++	530	++
Vegs., 100 feet	0.0032	++	780	++
Water, runoff	0.0001	++	++	++
Water, drift	0.0000	++	++	++
Dermal exposures				
At 25 feet	0.0014	++	++	++
At 100 feet	0.0009	++	++	++
Dog petting	0.0001	++	++	++

Table I-7--Margins of safety for workers
Nursery: Stone
Pesticide: Metalaxyl

		Margin of safety relative to:		
	Exposure (mg/kg/day)	LD_{50} (669.0)	Systemic NOEL (6.25)	Reproductive NOEL (50.00)
Average				
Applicator	0.0032	++	++	++
Weeder	0.1407	++	44	360
Inventory	0.0255	++	240	++
Lifting	0.0000	++	++	++
Extreme				
Applicator	0.0186	++	340	++
Weeder	1.0785	620	5.8	46
Inventory	1.0785	620	5.8	46
Lifting	0.0011	++	++	++
Accident spray	3.3000	200	1.9	15
Accident spill	120.0000	5.6	-19	-2.4
Premature reentry	0.4360	++	14	110

Margins of Safety for Exposed Members of the Public

		Margin of safety relative to:		
	Exposure (mg/kg/day)	LD_{50} (669.0)	Systemic NOEL (6.25)	Reproductive NOEL (50.00)
Average over applications				
Dietary exposures				
Beef	0.0002	++	++	++
Rabbit	0.0045	++	++	++
Grouse	0.0036	++	++	++
Vegs., 25 feet	0.0119	++	530	++
Vegs., 100 feet	0.0083	++	750	++
Water, runoff	0.0005	++	++	++
Water, drift	0.0000	++	++	++
Dermal exposures				
At 25 feet	0.0038	++	++	++
At 100 feet	0.0024	++	++	++
Dog petting	0.0002	++	++	++
Lowest margins of safety				
Dietary exposures				
Beef	0.0006	++	++	++
Rabbit	0.0140	++	450	++
Grouse	0.0110	++	570	++
Vegs., 25 feet	0.0370	++	170	++
Vegs., 100 feet	0.0260	++	240	++
Water, runoff	0.0015	++	++	++
Water, drift	0.0000	++	++	++
Dermal exposures				
At 25 feet	0.0120	++	520	++
At 100 feet	0.0074	++	840	++
Dog petting	0.0008	++	++	++

Table I-8--Margins of safety for workers
Nursery: Stone
Pesticide: Chlorpyrifos

	Exposure (mg/kg/day)	Margin of safety relative to: LD_{50} (137.0)	Systemic NOEL (0.03)	Reproductive NOEL (0.10)
Average				
Applicator	0.0055	++	5.4	18
Weeder	0.0218	++	1.4	4.6
Inventory	0.0037	++	8.1	27
Lifting	0.0000	++	++	++
Extreme				
Applicator	0.0140	++	2.2	7.2
Weeder	0.1035	++	-3.5	-1.0
Inventory	0.0291	++	1.0	3.4
Lifting	0.0000	++	++	++
Accident spray	0.4200	330	-14	-4.2
Accident spill	240.0000	-1.8	-8000	-2400
Premature reentry	0.1684	810	-5.6	-1.7

Margins of Safety for Exposed Members of the Public

	Exposure (mg/kg/day)	Margin of safety relative to: LD_{50} (137.0)	Systemic NOEL (0.03)	Reproductive NOEL (0.10)
Average over applications				
Dietary exposures				
Beef	0.0000	++	610	++
Rabbit	0.0017	++	18	59
Grouse	0.0014	++	21	71
Vegs., 25 feet	0.0047	++	6.4	21
Vegs., 100 feet	0.0032	++	9.4	31
Water, runoff	0.0001	++	470	++
Water, drift	0.0001	++	540	++
Dermal exposures				
At 25 feet	0.0014	++	21	71
At 100 feet	0.0009	++	33	110
Dog petting	0.0001	++	320	++
Lowest margins of safety				
Dietary exposures				
Beef	0.0000	++	610	++
Rabbit	0.0017	++	18	59
Grouse	0.0014	++	21	71
Vegs., 25 feet	0.0047	++	6.4	21
Vegs., 100 feet	0.0032	++	9.4	31
Water, runoff	0.0001	++	470	++
Water, drift	0.0001	++	540	++
Dermal exposures				
At 25 feet	0.0014	++	21	71
At 100 feet	0.0009	++	33	110
Dog petting	0.0001	++	320	++

Table I-9--Margins of safety for workers
Nursery: Stone
Pesticide: Fenvalerate

		Margin of safety relative to:		
	Exposure (mg/kg/day)	LD_{50} (1000.0)	Systemic NOEL (1.50)	Reproductive NOEL (12.50)
Average				
Applicator	0.0003	++	++	++
Weeder	0.0003	++	++	++
Inventory	0.0003	++	++	++
Lifting	0.0000	++	++	++
Extreme				
Applicator	0.0014	++	++	++
Weeder	0.0057	++	270	++
Inventory	0.0004	++	++	++
Lifting	0.0000	++	++	++
Accident spray	0.0420	++	36	300
Accident spill	140.0000	7.1	-93	-11
Premature reentry	0.0164	++	91	760

Margins of Safety for Exposed Members of the Public

		Margin of safety relative to:		
	Exposure (mg/kg/day)	LD_{50} (1000.0)	Systemic NOEL (1.50)	Reproductive NOEL (2.50)
Average over applications				
Dietary exposures				
Beef	0.0000	++	++	++
Rabbit	0.0002	++	++	++
Grouse	0.0001	++	++	++
Vegs., 25 feet	0.0005	++	++	++
Vegs., 100 feet	0.0003	++	++	++
Water, runoff	0.0000	++	++	++
Water, drift	0.0000	++	++	++
Dermal exposures				
At 25 feet	0.0001	++	++	++
At 100 feet	0.0001	++	++	++
Dog petting	0.0000	++	++	++
Lowest margins of safety				
Dietary exposures				
Beef	0.0000	++	++	++
Rabbit	0.0002	++	++	++
Grouse	0.0001	++	++	++
Vegs., 25 feet	0.0005	++	++	++
Vegs., 100 feet	0.0003	++	++	++
Water, runoff	0.0000	++	++	++
Water, drift	0.0000	++	++	++
Dermal exposures				
At 25 feet	0.0001	++	++	++
At 100 feet	0.0001	++	++	++
Dog petting	0.0000	++	++	++

Table I-10--Lifetime cancer risk for exposed members of the public
Nursery: Stone

	Oxyfluorfen
5 Exposures	
Rabbit	1.E-11
Vegs. (25 ft)	3.E-11
Water, drift	7.E-14
Dermal (25 ft)	9.E-12
30 Exposures	
Rabbit	7.E-11
Vegs. (25 ft)	2.E-10
Water, drift	4.E-13
Dermal (25 ft)	5.E-11

Table I-11--Lifetime cancer risk for workers
Nursery: Stone

	Oxyfluorfen
5 Years of exposure	
Weeding	3.E-09
Inventory	2.E-10
Lifting	6.E-12
Application	1.E-10
30 Years of exposure	
Weeding	2.E-08
Inventory	1.E-09
Lifting	3.E-11
Application	9.E-10

J. Toumey Nursery

EXPOSURE ANALYSIS METHODS

The Toumey Nursery is located in Michigan and has a total area of 110 acres and a total nursery bed area of 66 acres. All 66 bed-acres are treated with pesticides every year. The nursery generally employs the following number of personnel annually for its operations: 1 to 2 mixer/loader/applicators, 11 to 24 weeders, 3 to 4 inventory personnel, 20 to 40 lifters, 40 to 50 sorters and packers, 3 fumigators, and 3 to 6 tarp lifters.

The exposure analysis methods used to estimate doses to workers and the public in the Toumey Nursery were similar to those described for the generic nursery, except that conditions specific to the nursery, such as the pesticides used, the application rates, and the timing of the applications, were used in the analyses rather than the generic set of conditions. The pesticide application schedule for the nursery is given in table J-1. (Tables can be found at the end of this section.) Methyl bromide is applied on 10 to 15 acres in the spring or fall. Seeds are treated with captan from January to March. For the purpose of determining foliar washoff of pesticide residues, each bed was assumed to be irrigated every other day at a rate of 0.5 inches per day.

There is one Forest Service residence onsite and three Forest Service residences within 100 feet. The land bordering the nursery is predominantly residential or forest.

The nearest live water is a small stream approximately 150 feet from the nursery. There is no aquifer below the nursery. The soil type is sand loam and loam sand.

RISK ANALYSIS

Risk of Systemic and Reproductive Effects

Risks to members of the public and workers involved in pesticide applications and related nursery tasks in the Toumey Nursery are based on the methods described in chapters 3 and 4 of the generic nursery risk assessment. Tables J-2 through J-8 present exposure levels and margins of safety based on LD_{50}'s, systemic NOEL's, and reproductive NOEL's for routine-realistic (average), routine-extreme, and accidental exposures.

The MOS tables for each chemical consist of two parts. The first lists worker exposures and MOS's for the chemical as it is used in the Toumey Nursery. The worker portion lists MOS's for routine-realistic (average), routine-extreme (extreme), and accidental exposures (spraying, spills on the skin, and premature reentry). LD_{50}'s and NOEL's are listed above each column of MOS's.

The second portion of each table lists public exposures and MOS's via specific exposure routes for routine-realistic (average) and routine-extreme (lowest MOS's) exposures. The only accidents that may affect the public are assumed to be those involving fumigant spills. The analysis of fumigant spills is contained in the generic nursery risk analysis.

Dashes in the worker portion of the tables indicate that the chemical is used only in cover crops. Dashes in the public portion indicate that the route of exposure is not considered a significant one in this analysis. Margins of safety greater than 1,000 are indicated by ++.

Where MOS's are greater than 100, risk can be considered negligible for the chemical in question. MOS's between 10 and 100 indicate a slight risk of low-level toxic effects--to sensitive individuals in particular. MOS's between 1 and 10 indicate a moderate risk of low-level toxic effects, especially in light of the uncertainty in extrapolating from laboratory test animal species to humans. Risk may be significant where an MOS for a chemical is negative (the estimated exposure exceeds the animal NOEL). Refer to the discussion of low-level toxic effects in the generic nursery risk analysis.

Cancer Risk

Lifetime cancer risks to members of the public for the known or suspected carcinogenic chemicals oxyfluorfen, chlorothalonil, maneb, and carbaryl at the Toumey Nursery are listed in table J-9 for different exposure routes and number of lifetime exposures. Lifetime cancer risks to workers for the use of those chemicals in various nursery tasks are listed in table J-10. The cancer risk tables should be interpreted as follows. Where the exponent is lower, the risk is higher. For example, a risk value of 1.0E-06 (1 chance in 1 million) is lower than a risk of 1.0E-05 (1 chance in 100,000). A risk of 7.0E-06 exceeds a risk of 1.0E-06.

In general, risk may be considered acceptable where risk to an individual is equal to or lower than 1 in 1 million. Where risk exceeds 1 chance in 100,000, proper precautions that reduce exposure levels may, in turn, reduce the cancer risk to acceptable levels.

Table J-1--Toumey Nursery schedule for pesticide applications (based on average use)

Crop	Year	Chemical	Acres	Rate (lb/acre)	Applications per year	Month of application
Cover crop	0	Chlorothalonil	10	1.3	1	Nov
Pine	1	Chlorothalonil	11	1.3	7	Jun-Aug, Nov
Pine	1	Maneb	11	2.4	5	Aug-Oct
Pine	1	DCPA	11	9.0	2	May-Jun
Pine	1	Diazinon	6	4.25	1	Jun
Pine	1	Oxyfluorfen	11	0.5	2	May, Jun
Pine	1	Bifenox	11	3.0	2	May, Jun
Spruce	1	Chlorothalonil	2	1.3	1	Nov
Spruce	1	Diazinon	2	4.25	1	Jun
Spruce	1	Oxyfluorfen	2	0.5	2	May, Jun
Spruce	1	Bifenox	2	3.0	2	May, Jun
Spruce	1	DCPA	2	9.0	2	May-Jun
Hardwoods	1	Carbaryl	1	0.8	3	May-Jul
Pine	2	Chlorothalonil	12	1.3	10	May-Aug, Nov
Pine	2	Maneb	12	2.4	5	Aug-Oct
Spruce	2	Chlorothalonil	1.5	1.3	1	Nov
Hardwoods	2	Carbaryl	1	0.8	3	May-Jul
Pine	3	Chlorothalonil	5	1.3	10	May-Aug, Nov
Pine	3	Maneb	12	2.4	5	Aug-Oct
Spruce	3	Chlorothalonil	1	1.3	1	Nov
Seed treatment		Thiram				Before sowing

Table J-2--Margins of safety for workers
Nursery: Toumey
Pesticide: Bifenox

	Exposure (mg/kg/day)	Margin of safety relative to: LD_{50} (6400.0)	Systemic NOEL (12.50)	Reproductive NOEL (10.00)
Average				
Applicator	0.0060	++	++	++
Weeder	0.0039	++	++	++
Inventory	0.0097	++	++	1000
Lifting	0.0000	++	++	++
Extreme				
Applicator	0.0153	++	810	650
Weeder	0.1762	++	71	57
Inventory	0.3797	++	33	26
Lifting	0.0000	++	++	++
Accident spray	1.3000	++	9.6	7.7
Accident spill	120.0000	53	-9.6	-12
Premature reentry	0.5095	++	25	20

Margins of Safety for Exposed Members of the Public

	Exposure (mg/kg/day)	Margin of safety relative to: LD_{50} (6400.0)	Systemic NOEL (12.50)	Reproductive NOEL (10.00)
Average over applications				
Dietary exposures				
Beef	0.0002	++	++	++
Rabbit	0.0052	++	++	++
Grouse	0.0042	++	++	++
Vegs., 25 feet	0.0140	++	890	710
Vegs., 100 feet	0.0097	++	++	1000
Water, runoff	---	---	---	---
Water, drift	0.0000	++	++	++
Dermal exposures				
At 25 feet	0.0043	++	++	++
At 100 feet	0.0028	++	++	++
Dog petting	0.0003	++	++	++
Lowest margins of safety				
Dietary exposures				
Beef	0.0002	++	++	++
Rabbit	0.0052	++	++	++
Grouse	0.0042	++	++	++
Vegs., 25 feet	0.0140	++	890	710
Vegs., 100 feet	0.0097	++	++	1000
Water, runoff	---	---	---	---
Water, drift	0.0000	++	++	++
Dermal exposures				
At 25 feet	0.0043	++	++	++
At 100 feet	0.0028	++	++	++
Dog petting	0.0003	++	++	++

Table J-3--Margins of safety for workers
Nursery: Toumey
Pesticide: DCPA

	Exposure (mg/kg/day)	Margin of safety relative to: LD_{50} (10250.0)	Systemic NOEL (50.00)	Reproductive NOEL (50.00)
Average				
Applicator	0.0181	++	++	++
Weeder	0.0822	++	610	610
Inventory	0.0529	++	950	950
Lifting	0.0000	++	++	++
Extreme				
Applicator	0.0460	++	++	++
Weeder	0.8347	++	60	60
Inventory	0.8347	++	60	60
Lifting	0.0000	++	++	++
Accident spray	3.8000	++	13	13
Accident spill	360.0000	28	-7.2	-7.2
Premature reentry	1.5369	++	33	33

Margins of Safety for Exposed Members of the Public

	Exposure (mg/kg/day)	Margin of safety relative to: LD_{50} (10250.0)	Systemic NOEL (50.00)	Reproductive NOEL (50.00)
Average over applications				
Dietary exposures				
Beef	0.0008	++	++	++
Rabbit	0.0150	++	++	++
Grouse	0.0130	++	++	++
Vegs., 25 feet	0.0420	++	++	++
Vegs., 100 feet	0.0290	++	++	++
Water, runoff	---	---	---	---
Water, drift	0.0000	++	++	++
Dermal exposures				
At 25 feet	0.0130	++	++	++
At 100 feet	0.0083	++	++	++
Dog petting	0.0008	++	++	++
Lowest margins of safety				
Dietary exposures				
Beef	0.0008	++	++	++
Rabbit	0.0150	++	++	++
Grouse	0.0130	++	++	++
Vegs., 25 feet	0.0420	++	++	++
Vegs., 100 feet	0.0290	++	++	++
Water, runoff	---	---	---	---
Water, drift	0.0000	++	++	++
Dermal exposures				
At 25 feet	0.0130	++	++	++
At 100 feet	0.0083	++	++	++
Dog petting	0.0008	++	++	++

Table J-4--Margins of safety for workers
Nursery: Toumey
Pesticide: Oxyfluorfen

		Margin of safety relative to:		
	Exposure (mg/kg/day)	LD_{50} (5000.0)	Systemic NOEL (0.30)	Reproductive NOEL (0.50)
Average				
Applicator	0.0010	++	300	500
Weeder	0.0016	++	190	310
Inventory	0.0001	++	++	++
Lifting	0.0000	++	++	++
Extreme				
Applicator	0.0026	++	120	200
Weeder	0.0363	++	8.3	14
Inventory	0.0672	++	4.5	7.4
Lifting	0.0000	++	++	++
Accident spray	0.2100	++	1.4	2.4
Accident spill	120.0000	42	-400	-240
Premature reentry	0.0851	++	3.5	5.9

Margins of Safety for Exposed Members of the Public

		Margin of safety relative to:		
	Exposure (mg/kg/day)	LD_{50} (5000.0)	Systemic NOEL (0.30)	Reproductive NOEL (0.50)
Average over applications				
Dietary exposures				
Beef	0.0000	++	++	++
Rabbit	0.0009	++	350	580
Grouse	0.0007	++	430	710
Vegs., 25 feet	0.0023	++	130	220
Vegs., 100 feet	0.0016	++	190	310
Water, runoff	---	---	---	---
Water, drift	0.0000	++	++	++
Dermal exposures				
At 25 feet	0.0007	++	420	690
At 100 feet	0.0005	++	650	++
Dog petting	0.0000	++	++	++
Lowest margins of safety				
Dietary exposures				
Beef	0.0000	++	++	++
Rabbit	0.0009	++	350	580
Grouse	0.0007	++	430	710
Vegs., 25 feet	0.0023	++	130	220
Vegs., 100 feet	0.0016	++	190	310
Water, runoff	---	---	---	---
Water, drift	0.0000	++	++	++
Dermal exposures				
At 25 feet	0.0007	++	420	690
At 100 feet	0.0005	++	650	++
Dog petting	0.0000	++	++	++

Table J-5--Margins of safety for workers
Nursery: Toumey
Pesticide: Chlorothalonil

	Exposure (mg/kg/day)	Margin of safety relative to: LD_{50} (10000.0)	Systemic NOEL (1.50)	Reproductive NOEL (5.00)
Average				
Applicator	0.0027	++	550	++
Weeder	0.0880	++	17	57
Inventory	0.0240	++	62	210
Lifting	0.0012	++	++	++
Extreme				
Applicator	0.0073	++	210	690
Weeder	0.1881	++	8.0	27
Inventory	0.1220	++	12	41
Lifting	0.0763	++	20	66
Accident spray	0.5400	++	2.8	9.3
Accident spill	360.0000	28	-240	-72
Premature reentry	0.2135	++	7.0	23

Margins of Safety for Exposed Members of the Public

	Exposure (mg/kg/day)	Margin of safety relative to: LD_{50} (10000.0)	Systemic NOEL (1.50)	Reproductive NOEL (5.00)
Average over applications				
Dietary exposures				
Beef	0.0001	++	++	++
Rabbit	0.0022	++	680	++
Grouse	0.0018	++	830	++
Vegs., 25 feet	0.0061	++	250	820
Vegs., 100 feet	0.0042	++	360	++
Water, runoff	---	---	---	---
Water, drift	0.0000	++	++	++
Dermal exposures				
At 25 feet	0.0019	++	790	++
At 100 feet	0.0012	++	++	++
Dog petting	0.0001	++	++	++
Lowest margins of safety				
Dietary exposures				
Beef	0.0001	++	++	++
Rabbit	0.0022	++	680	++
Grouse	0.0018	++	830	++
Vegs., 25 feet	0.0061	++	250	820
Vegs., 100 feet	0.0042	++	360	++
Water, runoff	---	---	---	---
Water, drift	0.0000	++	++	++
Dermal exposures				
At 25 feet	0.0019	++	790	++
At 100 feet	0.0012	++	++	++
Dog petting	0.0001	++	++	++

Table J-6--Margins of safety for workers
Nursery: Toumey
Pesticide: Maneb

	Exposure (mg/kg/day)	Margin of safety relative to: LD_{50} (4500.0)	Systemic NOEL (2.00)	Reproductive NOEL (5.00)
Average				
Applicator	0.0059	++	340	850
Weeder	0.1404	++	14	36
Inventory	---	---	---	---
Lifting	0.0045	++	450	++
Extreme				
Applicator	0.0134	++	150	370
Weeder	0.3294	++	6.1	15
Inventory	---	---	---	---
Lifting	0.0481	++	42	100
Accident spray	1.0000	++	2.0	5.0
Accident spill	240.0000	19	-120	-48
Premature reentry	0.4090	++	4.9	12

Margins of Safety for Exposed Members of the Public

	Exposure (mg/kg/day)	Margin of safety relative to: LD_{50} (4500.0)	Systemic NOEL (2.00)	Reproductive NOEL (5.00)
Average over applications				
Dietary exposures				
Beef	0.0002	++	++	++
Rabbit	0.0041	++	490	++
Grouse	0.0034	++	590	++
Vegs., 25 feet	0.0110	++	180	450
Vegs., 100 feet	0.0077	++	260	650
Water, runoff	---	---	---	---
Water, drift	0.0000	++	++	++
Dermal exposures				
At 25 feet	0.0035	++	570	++
At 100 feet	0.0022	++	910	++
Dog petting	0.0002	++	++	++
Lowest margins of safety				
Dietary exposures				
Beef	0.0002	++	++	++
Rabbit	0.0041	++	490	++
Grouse	0.0034	++	590	++
Vegs., 25 feet	0.0110	++	180	450
Vegs., 100 feet	0.0077	++	260	650
Water, runoff	---	---	---	---
Water, drift	0.0000	++	++	++
Dermal exposures				
At 25 feet	0.0035	++	570	++
At 100 feet	0.0022	++	910	++
Dog petting	0.0002	++	++	++

Table J-7--Margins of safety for workers
Nursery: Toumey
Pesticide: Carbaryl

	Exposure (mg/kg/day)	Margin of safety relative to: LD_{50} (270.0)	Systemic NOEL (10.00)	Reproductive NOEL (3.13)
Average				
Applicator	0.0002	++	++	++
Weeder	0.0324	++	310	96
Inventory	0.0007	++	++	++
Lifting	0.0000	++	++	++
Extreme				
Applicator	0.0004	++	++	++
Weeder	0.0989	++	100	32
Inventory	0.0115	++	870	270
Lifting	0.0000	++	++	++
Accident spray	0.3300	820	30	9.5
Accident spill	240.0000	1.1	-24	-77
Premature reentry	0.1357	++	74	23

Margins of Safety for Exposed Members of the Public

	Exposure (mg/kg/day)	Margin of safety relative to: LD_{50} (270.0)	Systemic NOEL (10.00)	Reproductive NOEL (3.13)
Average over applications				
Dietary exposures				
Beef	0.0001	++	++	++
Rabbit	0.0014	++	++	++
Grouse	0.0011	++	++	++
Vegs., 25 feet	0.0037	++	++	840
Vegs., 100 feet	0.0026	++	++	++
Water, runoff	---	---	---	---
Water, drift	0.0000	++	++	++
Dermal exposures				
At 25 feet	0.0012	++	++	++
At 100 feet	0.0007	++	++	++
Dog petting	0.0001	++	++	++
Lowest margins of safety				
Dietary exposures				
Beef	0.0001	++	++	++
Rabbit	0.0014	++	++	++
Grouse	0.0011	++	++	++
Vegs., 25 feet	0.0037	++	++	840
Vegs., 100 feet	0.0026	++	++	++
Water, runoff	---	---	---	---
Water, drift	0.0000	++	++	++
Dermal exposures				
At 25 feet	0.0012	++	++	++
At 100 feet	0.0007	++	++	++
Dog petting	0.0001	++	++	++

Table J-8--Margins of safety for workers
Nursery: Toumey
Pesticide: Diazinon

	Exposure (mg/kg/day)	Margin of safety relative to: LD_{50} (250.0)	Systemic NOEL (0.02)	Reproductive NOEL (0.20)
Average				
Applicator	0.0044	++	4.5	45
Weeder	0.1332	++	-6.7	1.5
Inventory	0.0002	++	120	++
Lifting	0.0000	++	++	++
Extreme				
Applicator	0.0119	++	1.7	17
Weeder	0.4880	510	-24	-2.4
Inventory	0.0128	++	1.6	16
Lifting	0.0000	++	++	++
Accident spray	1.8000	140	-90	-9.0
Accident spill	360.0000	-1.4	-18000	-1800
Premature reentry	0.7189	350	-36	-3.6

Margins of Safety for Exposed Members of the Public

	Exposure (mg/kg/day)	Margin of safety relative to: LD_{50} (250.0)	Systemic NOEL (0.02)	Reproductive NOEL (0.20)
Average over applications				
Dietary exposures				
Beef	0.0003	++	77	770
Rabbit	0.0073	++	2.7	27
Grouse	0.0060	++	3.3	33
Vegs., 25 feet	0.0200	++	-1.0	10.0
Vegs., 100 feet	0.0140	++	1.4	14
Water, runoff	---	---	---	---
Water, drift	0.0000	++	950	++
Dermal exposures				
At 25 feet	0.0062	++	3.2	32
At 100 feet	0.0039	++	5.1	51
Dog petting	0.0004	++	50	500
Lowest margins of safety				
Dietary exposures				
Beef	0.0003	++	77	770
Rabbit	0.0073	++	2.7	27
Grouse	0.0060	++	3.3	33
Vegs., 25 feet	0.0200	++	-1.0	10.0
Vegs., 100 feet	0.0140	++	1.4	14
Water, runoff	---	---	---	---
Water, drift	0.0000	++	950	++
Dermal exposures				
At 25 feet	0.0062	++	3.2	32
At 100 feet	0.0039	++	5.1	51
Dog petting	0.0004	++	50	500

Table J-9--Lifetime cancer risk for exposed members of the public
Nursery: Toumey

	Oxyfluorfen	Chlorothalonil	Maneb	Carbaryl
5 Exposures				
Rabbit	5.E-12	1.E-08	4.E-07	4.E-08
Vegs. (25 ft)	1.E-11	3.E-08	1.E-06	1.E-07
Water, drift	1.E-13	1.E-10	1.E-09	1.E-09
Dermal (25 ft)	4.E-12	9.E-09	4.E-07	----
30 Exposures				
Rabbit	3.E-11	6.E-08	3.E-06	2.E-07
Vegs. (25 ft)	8.E-11	2.E-07	7.E-06	6.E-07
Water, drift	7.E-13	6.E-10	8.E-09	6.E-09
Dermal (25 ft)	2.E-11	5.E-08	2.E-06	----

Table J-10--Lifetime cancer risk for workers
Nursery: Toumey

	Oxyfluorfen	Chlorothalonil	Maneb
5 Years of exposure			
Weeding	1.E-10	2.E-05	7.E-04
Inventory	5.E-12	2.E-06	----
Lifting	1.E-14	2.E-07	2.E-05
Application	2.E-12	6.E-08	2.E-06
30 Years of exposure			
Weeding	9.E-10	1.E-04	4.E-03
Inventory	3.E-11	1.E-05	----
Lifting	9.E-14	1.E-06	1.E-04
Application	1.E-11	3.E-07	1.E-05

K. Wind River Nursery

EXPOSURE ANALYSIS METHODS

The Wind River Nursery is located in the State of Washington and has a total area of 131 acres and a total nursery bed area of 118 acres. All 118 bed-acres are treated with pesticides every year. The nursery generally employs the following number of personnel annually for its operations: 2 to 6 mixer/loader/applicators, 11 to 24 weeders, 18 to 24 inventory personnel, 50 to 150 lifters, 120 to 150 sorters and packers, 7 fumigators, and 3 to 6 tarp lifters.

The exposure analysis methods used to estimate doses to workers and the public in the Wind River Nursery were similar to those described for the generic nursery, except that the conditions specific to the nursery, such as the pesticides used, the application rates, and the timing of the applications, were used in the analyses rather than the generic set of conditions. The pesticide application schedule for the nursery is shown in table K-1. (Tables are at the end of this section.) For the purposes of determining foliar washoff of pesticide residues, each bed was assumed to be irrigated every other day at a rate of 0.25 inches per day. Methyl bromide is applied to approximately 55 acres in April or September.

There are 10 Forest Service residences onsite and 16 residences within 100 feet. The land bordering the nursery is entirely forest land.

The nearest live water includes a drainage ditch and a creek approximately 20 feet and 100 feet, respectively, from the nursery. An aquifer is located at a depth of 50 feet. The soil is predominantly Stablershotty loam.

RISK ANALYSIS

Risk of Systemic and Reproductive Effects

Risks to members of the public and workers involved in pesticide applications and related nursery tasks in the Wind River Nursery are based on the methods described in chapters 3 and 4 of the generic nursery risk assessment. Tables K-2 through K-5 present exposure levels and margins of safety based on LD_{50}'s, systemic NOEL's, and reproductive NOEL's for routine-realistic (average), routine-extreme, and accidental exposures.

The MOS tables for each chemical consist of two parts. The first lists worker exposures and MOS's for the chemical as it is used in the Wind River Nursery. The worker portion lists MOS's for routine-realistic (average), routine-extreme (extreme), and accidental exposures (spraying, spills on the skin, and premature reentry). LD_{50}'s and NOEL's are listed above each column of MOS's.

The second portion of each table lists public exposures and MOS's via specific exposure routes for routine-realistic (average) and routine-extreme (lowest MOS's) exposures. The only accidents that may

affect the public are assumed to be those involving fumigant spills. The analysis of fumigant spills is contained in the generic nursery risk analysis.

Dashes in the worker portion of the tables indicate that the chemical is used only in cover crops. Dashes in the public portion indicate that the route of exposure is not considered a significant one in this analysis. Margins of safety greater than 1,000 are indicated by ++.

Where MOS's are greater than 100, risk can be considered negligible for the chemical in question. MOS's between 10 and 100 indicate a slight risk of low-level toxic effects--to sensitive individuals in particular. MOS's between 1 and 10 indicate a moderate risk of low-level toxic effects, especially in light of the uncertainty in extrapolating from laboratory test animal species to humans. Risk may be significant where an MOS for a chemical is negative (the estimated exposure exceeds the animal NOEL). Refer to the discussion of low-level toxic effects in the generic nursery risk analysis.

Cancer Risk

Lifetime cancer risks for chlorothalonil and benomyl to members of the public at the Wind River Nursery are listed in table K-6 for different exposure routes and numbers of lifetime exposures. Lifetime cancer risks to workers from the use of benomyl in root treatment are listed in table K-7. The cancer risk tables should be interpreted as follows. Where the exponent is lower, the risk is higher. For example, a risk value of 1.0E-06 (1 chance in 1 million) is lower than a risk of 1.0E-05 (1 chance in 100,000). A risk of 7.0E-06 exceeds a risk of 1.0E-06.

In general, risk may be considered acceptable where risk to an individual is equal to or lower than 1 in 1 million. Where risk exceeds 1 chance in 100,000, proper precautions that reduce exposure levels may, in turn, reduce the cancer risk to acceptable levels.

Table K-1--Wind River Nursery schedule for pesticide applications (based on average use)

Crop	Year	Chemical	Acres	Rate (lb/acre)	Applications per year	Month of application
Pine	1	DCPA or diphenamid	13.3	10.5	1	Aug
Douglas-fir	1	DCPA or diphenamid	13.3	10.5	1	Aug
Other conifers	1	DCPA or diphenamid	13.4	10.5	1	Aug
Other conifers	1	Chlorothalonil and benomyl	0.5	0.5/0.25	2	Jul-Aug
Pine	2	Chlorothalonil and benomyl	13.3	0.5/0.25	9	Apr-Jul, Oct
Pine	2	DCPA or diphenamid	13.3	10.5	1	Apr
Douglas-fir	2	DCPA or diphenamid	13.3	10.5	1	Apr
Douglas-fir	2	Chlorothalonil and benomyl	13.3	0.5/0.25	9	Apr-Jul, Oct
Other conifers	2	DCPA or diphenamid	13.4	10.5	1	Apr
Other conifers	2	Chlorothalonil and benomyl	13.4	0.5/0.25	9	Apr-Jul, Oct
Pine	3	Chlorothalonil and benomyl	0.3	0.5/0.25	9	Apr-Jul, Oct
Douglas-fir	3	Chlorothalonil and benomyl	0.3	0.5/0.25	9	Apr-Jul, Oct
Other conifers	3	Chlorothalonil and benomyl	0.3	0.5/0.25	9	Apr-Jul, Oct

Table K-2--Margins of safety for workers
Nursery: Wind River
Pesticide: DCPA

	Exposure (mg/kg/day)	Margin of safety relative to: LD_{50} (10250.0)	Systemic NOEL (50.00)	Reproductive NOEL (50.00)
Average				
Applicator	0.0293	++	++	++
Weeder	0.2487	++	200	200
Inventory	0.1875	++	270	270
Lifting	0.0021	++	++	++
Extreme				
Applicator	0.0654	++	760	760
Weeder	1.2162	++	41	41
Inventory	1.2162	++	41	41
Lifting	0.0026	++	++	++
Accident spray	4.4000	++	11	11
Accident spill	360.0000	28	-7.2	-7.2
Premature reentry	1.7979	++	28	28

Margins of Safety for Exposed Members of the Public

	Exposure (mg/kg/day)	Margin of safety relative to: LD_{50} (10250.0)	Systemic NOEL (50.00)	Reproductive NOEL (50.00)
Average over applications				
Dietary exposures				
Beef	0.0009	++	++	++
Rabbit	0.0180	++	++	++
Grouse	0.0150	++	++	++
Vegs., 25 feet	0.0490	++	1000	1000
Vegs., 100 feet	0.0340	++	++	++
Water, runoff	0.0006	++	++	++
Water, drift	0.0000	++	++	++
Dermal exposures				
At 25 feet	0.0150	++	++	++
At 100 feet	0.0097	++	++	++
Dog petting	0.0010	++	++	++
Lowest margins of safety				
Dietary exposures				
Beef	0.0009	++	++	++
Rabbit	0.0180	++	++	++
Grouse	0.0150	++	++	++
Vegs., 25 feet	0.0490	++	1000	1000
Vegs., 100 feet	0.0340	++	++	++
Water, runoff	0.0006	++	++	++
Water, drift	0.0000	++	++	++
Dermal exposures				
At 25 feet	0.0150	++	++	++
At 100 feet	0.0097	++	++	++
Dog petting	0.0010	++	++	++

Table K-3--Margins of safety for workers
Nursery: Wind River
Pesticide: Diphenamid

	Exposure (mg/kg/day)	Margin of safety relative to: LD_{50} (1373.0)	Systemic NOEL (3.00)	Reproductive NOEL (10.00)
Average				
Applicator	0.0293	++	100	340
Weeder	0.0388	++	77	260
Inventory	0.0041	++	730	++
Lifting	0.0000	++	++	++
Extreme				
Applicator	0.0654	++	46	150
Weeder	0.7886	++	3.8	13
Inventory	0.7886	++	3.8	13
Lifting	0.0000	++	++	++
Accident spray	4.4000	310	-1.5	2.3
Accident spill	---	---	---	---
Premature reentry	1.7886	770	1.7	5.6

Margins of Safety for Exposed Members of the Public

	Exposure (mg/kg/day)	Margin of safety relative to: LD_{50} (1373.0)	Systemic NOEL (3.00)	Reproductive NOEL (10.00)
Average over applications				
Dietary exposures				
Beef	0.0008	++	++	++
Rabbit	0.0180	++	170	560
Grouse	0.0150	++	200	670
Vegs., 25 feet	0.0490	++	61	200
Vegs., 100 feet	0.0340	++	88	290
Water, runoff	0.0010	++	++	++
Water, drift	0.0002	++	++	++
Dermal exposures				
At 25 feet	0.0150	++	200	670
At 100 feet	0.0097	++	310	1000
Dog petting	0.0010	++	++	++
Lowest margins of safety				
Dietary exposures				
Beef	0.0008	++	++	++
Rabbit	0.0180	++	170	560
Grouse	0.0150	++	200	670
Vegs., 25 feet	0.0490	++	61	200
Vegs., 100 feet	0.0340	++	88	290
Water, runoff	0.0010	++	++	++
Water, drift	0.0002	++	++	++
Dermal exposures				
At 25 feet	0.0150	++	200	670
At 100 feet	0.0097	++	310	1000
Dog petting	0.0010	++	++	++

Table K-4--Margins of safety for workers
Nursery: Wind River
Pesticide: Benomyl

	Exposure (mg/kg/day)	Margin of safety relative to: LD_{50} (10000.0)	Systemic NOEL (12.50)	Reproductive NOEL (5.00)
Average				
Applicator	0.0007	++	++	++
Weeder	0.0222	++	560	230
Inventory	0.0069	++	++	730
Lifting	0.0004	++	++	++
Extreme				
Applicator	0.0016	++	++	++
Weeder	0.0387	++	320	130
Inventory	0.0387	++	320	130
Lifting	0.0049	++	++	1000
Accident spray	0.1000	++	130	50
Accident spill	---	---	---	---
Premature reentry	0.0428	++	290	120

Margins of Safety for Exposed Members of the Public

	Exposure (mg/kg/day)	Margin of safety relative to: LD_{50} (10000.0)	Systemic NOEL (12.50)	Reproductive NOEL (5.00)
Average over applications				
Dietary exposures				
Beef	0.0000	++	++	++
Rabbit	0.0004	++	++	++
Grouse	0.0003	++	++	++
Vegs., 25 feet	0.0012	++	++	++
Vegs., 100 feet	0.0008	++	++	++
Water, runoff	0.0000	++	++	++
Water, drift	0.0000	++	++	++
Dermal exposures				
At 25 feet	0.0004	++	++	++
At 100 feet	0.0002	++	++	++
Dog petting	0.0000	++	++	++
Lowest margins of safety				
Dietary exposures				
Beef	0.0000	++	++	++
Rabbit	0.0004	++	++	++
Grouse	0.0003	++	++	++
Vegs., 25 feet	0.0012	++	++	++
Vegs., 100 feet	0.0008	++	++	++
Water, runoff	0.0000	++	++	++
Water, drift	0.0000	++	++	++
Dermal exposures				
At 25 feet	0.0004	++	++	++
At 100 feet	0.0002	++	++	++
Dog petting	0.0000	++	++	++

Table K-5--Margins of safety for workers
Nursery: Wind River
Pesticide: Chlorothalonil

	Exposure (mg/kg/day)	Margin of safety relative to: LD_{50} (10000.0)	Systemic NOEL (1.50)	Reproductive NOEL (5.00)
Average				
Applicator	0.0014	++	++	++
Weeder	0.0439	++	34	110
Inventory	0.0193	++	78	260
Lifting	0.0032	++	470	++
Extreme				
Applicator	0.0031	++	480	++
Weeder	0.0771	++	19	65
Inventory	0.0586	++	26	85
Lifting	0.0472	++	32	110
Accident spray	0.2100	++	7.1	24
Accident spill	360.0000	28	-240	-72
Premature reentry	0.0856	++	18	58

Margins of Safety for Exposed Members of the Public

	Exposure (mg/kg/day)	Margin of safety relative to: LD_{50} (10000.0)	Systemic NOEL (1.50)	Reproductive NOEL (5.00)
Average over applications				
Dietary exposures				
Beef	0.0000	++	++	++
Rabbit	0.0009	++	++	++
Grouse	0.0007	++	++	++
Vegs., 25 feet	0.0023	++	650	++
Vegs., 100 feet	0.0016	++	940	++
Water, runoff	0.0000	++	++	++
Water, drift	0.0002	++	++	++
Dermal exposures				
At 25 feet	0.0007	++	++	++
At 100 feet	0.0005	++	++	++
Dog petting	0.0000	++	++	++
Lowest margins of safety				
Dietary exposures				
Beef	0.0000	++	++	++
Rabbit	0.0009	++	++	++
Grouse	0.0007	++	++	++
Vegs., 25 feet	0.0023	++	650	++
Vegs., 100 feet	0.0016	++	940	++
Water, runoff	0.0000	++	++	++
Water, drift	0.0002	++	++	++
Dermal exposures				
At 25 feet	0.0007	++	++	++
At 100 feet	0.0005	++	++	++
Dog petting	0.0000	++	++	++

Table K-6--Lifetime cancer risk for exposed members of the public
Nursery: Wind River

	Chlorothalonil	Benomyl
5 Exposures		
Rabbit	4.E-09	6.E-10
Vegs. (25 ft)	1.E-08	2.E-09
Water, drift	8.E-10	1.E-11
Dermal (25 ft)	3.E-09	5.E-10
30 Exposures		
Rabbit	2.E-08	3.E-09
Vegs. (25 ft)	6.E-08	9.E-09
Water, drift	5.E-09	6.E-11
Dermal (25 ft)	2.E-08	3.E-09

Table K-7--Lifetime cancer risk for workers
Nursery: Wind River

	Chlorothalonil	Benomyl
5 Years of exposure		
Weeding	5.E-06	6.E-07
Inventory	9.E-07	9.E-08
Lifting	3.E-07	8.E-09
Application	4.E-08	5.E-09
30 Years of exposure		
Weeding	3.E-05	4.E-06
Inventory	5.E-06	5.E-07
Lifting	2.E-06	5.E-08
Application	2.E-07	3.E-08

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